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Stikine-Iskut Development

Interim Assessment Report

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PREFACE

The study of the potential Stikine-Iskut hydroelectric development was halted in 1983 because of a reduction in the forecast future demand for electrical energy in the Province of British Columbia. The Interim Assessment Report provides for the records of B.C. Hydro an inventory of the Study undertaken and an interim assessment of the development based on that inventory as well as a recommendation for further studies if and when interest in the development is reactivated.

Environmental aspects of the Interim Assessment Report have been prepared by B.C. Hydro employees or by consultants to B.C. Hydro.

The Interim Assessment Report is based on studies which may be incomplete. All inventory and assessment set out in the report must be viewed as being subject to later verification or to change, having due regard for changing circumstances.

EXECUTIVE SUMMARY

B.C. Hydro commenced studies of hydroelectric power development on the Stikine and Iskut rivers in northwestern B.C. in 1977. The results of these studies indicate that this power development would be an attractive source of energy following completion of project developments on the Peace and Columbia rivers.

Studies and investigations of the Stikine-Iskut development were interrupted in 1983 as a result of a reduced forecast of the need for new sources of electrical energy. This Interim Assessment Report has been prepared to provide an overall reference to the work undertaken to the time of deferment and an assessment of the results of all studies and investigations completed.

At the time of deferment, generation studies were part way through preliminary design Phase I. Hence site investigations and engineering studies required to select the optimum layouts for each project have not been completed. Also, the detailed environmental studies had not reached a stage sufficient for energy project licence application. Preferred transmission corridors required to transmit energy from the proposed generation projects to the existing system grid have been selected and agreed to by the EPCC.* However, the detailed engineering and environmental studies required to select a transmission route within these corridors were deferred in 1983 just as these studies were commencing. Therefore, more studies and investigations must be carried out before an application for an energy project certificate for this potential power development can be made. It is estimated that about 5 years of data collection including 2½ years of further study would be required.

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* Energy Project Coordinating Committee of Provincial Government.

A public information program was carried out during the previous studies and investigations. However, much more effort and planning will need to be applied early in any future program if B.C. Hydro is to be successful in informing and consulting the public about the project.

The main conclusions reached in the studies and investigations completed to date are as follows:

I. OPTIMUM POWER DEVELOPMENT

a) Generation

Studies undertaken to date indicate that the optimum power development on the Stikine and Iskut rivers would consist of four generation projects as follows:

River	Project	Powerplant Capacity MW	Dam Height M	Reservoir Area ha
Stikine	Stikine Canyon	960	270	12600
Stikine	Tanzilla	960	193	850
Iskut	Iskut Canyon	810	175	3700
More Creek	More Creek*	170	145	4300
	Total Capacity	2900		

* Includes Forrest Kerr Creek Diversion.

Sufficient engineering investigations and analyses have been completed to determine that dams of the heights proposed at each project site would be technically feasible. However more investigations and studies are required to confirm the type of dam best suited to each site.

Preliminary designs for several types of dams for each of the projects have been prepared and one layout for each project is featured. The layout featured is either the layout which is expected to be the most economic or that which is most conservative based on our current knowledge of the site foundations.

Future studies should specifically address the following key unknowns identified in the work completed to date.

1) The risk and potential effect of renewed volcanic activity in the area adjacent to the Iskut Canyon site.

2) The potential for seismic activity in the Iskut Canyon area (possibly reservoir triggered) and the risk of differential movement along shears in the foundation rock.

3) The amount of seepage losses expected and the extent of seepage control measures required under the lava flats area at Iskut Canyon.

4) The extent and nature of sliding and slumping that could occur in identified areas along each of the proposed reservoirs which would appear to be susceptible to instability.

All generation engineering work has been reviewed by the Stikine-Iskut Engineering Advisory Board. The Board was appointed in 1981 and met three times, the last of which was in September 1983. At that time the Board generally concurred with the studies, designs and investigations completed to date as well as the future studies required to complete preliminary design.

b) Transmission

The optimum system for transmitting electrical energy from the Stikine-Iskut generation sites to the existing electric grid would be three 500 kV lines to the Telkwa substation near Smithers generally following a route close to Highway 37. Power from each of the generating stations would first be connected to collector stations via 500 kV or 230 kV lines before being transmitted south to the existing grid.

No unusual engineering problems are expected in constructing and maintaining the transmission lines along the proposed preliminary route with the exception of the Ningunsaw Pass.

The Ningunsaw Pass is very narrow and contains Highway 37 and an ecological reserve. Snow Avalanches are common. Detailed engineering study is required to locate a technically acceptable route and line configuration through this confined and hazardous area.

II. COSTS AND BENEFITS

a) Capital Costs

The estimated capital costs of each of the projects and the total development are as follows. The costs are in October 1984 $ million and allowances are shown for corporate overhead.

	Direct Cost	Overhead	Total
Stikine Canyon	1997	180	2177
Tanzilla	1170	105	1275
Iskut Canyon	1174	106	1280
More Creek	418	38	456
Transmission	673	60	733
Development Total	5432	489	5921
System Reinforcement	339	30	369
Total	5771	519	6290

b) Power Benefits

The estimated firm and secondary energy benefits and capacity benefits for the total development are as follows:

Annual firm energy	-	13120 GWh
Av. Annual secondary energy	-	2240 GWh
Dependable capacity	-	2810 MW

These values were determined by simulation of the total projected electric system, including Peace Site C, Keenleyside and Murphy Creek, with and without the Stikine-Iskut development.

c) Value and Cost of Benefits

Using the latest values for energy and capacity (1983) the Stikine-Iskut development would have a benefit to cost ratio of 1.14. Energy values are determined as the average cost of energy of the projects being considered for future development including the Stikine-Iskut development, and alternatives to the Stikine-Iskut. Averages are taken of three sequences of alternative projects and the full range of probable load forecast.

The estimated unit cost of firm energy in 1983 dollars is 19.1 mills/kWh at a 4% discount rate excluding taxes.

III. ENVIRONMENTAL AND SOCIO-ECONOMIC IMPACTS

a) General

Detailed environmental studies for the generation projects were undertaken from 1978 to 1983. Preliminary environmental studies of the several possible transmission corridors also commenced in 1978 and were completed in 1982. The environmental studies addressed the following disciplines:

- Climate and Air Quality
- Terrain and Geological Resources
- Vegetation
- Agriculture
- Forestry
- Water Resources
- Aquatic Resources
- Wildlife
- Recreation
- Visual Resources
- Heritage
- Land Use
- Socio-Economic Studies
- Settlement Studies
- Resource Evaluation

The following summarizes the major impacts identified in these assessments.

b) Aquatic Resources

The Stikine and Iskut rivers support small but important runs of all five species of Pacific salmon as well as Steelhead trout. These fish are caught commercially primarily by Alaskan fishermen although a small commercial fishery has recently been developed in the Canadian section of the lower Stikine River. The commercial catch of Stikine salmon has declined significantly in recent years, particularly catches of chinook and coho.

The effects of the development on fish habitat are in many cases complex and hence difficult to predict. In addition, basic knowledge of Stikine fisheries is insufficient to allow precise prediction of the effects of changes in habitat or even in some cases whether such changes would be positive or negative. Major impacts on fisheries resources could result from:

1) a more stabilized seasonal flow regime which in the long term would reduce the extent of river secondary channels and lower summer water levels. These changes would reduce the amount of salmon fry rearing habitat and sockeye spawning habitat.

2) short term fluctuations in river discharge resulting from hourly, daily and weekly changes in power demand. These fluctuations could interrupt mainstem spawning, expose redds and strand fish.

3) seasonal changes in river water temperatures downstream of the proposed projects due to the storage of water in the reservoirs. Warmer winter temperatures could affect egg incubation rates and hence fry survival. Colder summer temperatures could affect fry growth rates.

Although our knowledge of these impacts needs to be improved, it can be stated that all aquatic impacts can either be mitigated by altering project design and operation or can be compensated for by developing alternative habitat.

c) Wildlife Resources

The major impact on wildlife resources in the project areas would be the flooding of 17,000 ha of habitat by the proposed reservoirs. This loss cannot be avoided if the development proceeds and is estimated to result in a loss of 120 moose, 55 goats, 80 bears and numerous furbearers and birds.

Other wildlife impacts could result from transmission line clearing, new access into wilderness areas and increased hunting pressures. These impacts can be mitigated by careful transmission route location, access road design and control, and hunting restrictions.

Impacts on wildlife may also occur indirectly due to changes in vegetation succession in the floodplain areas downstream of the proposed projects and in the estuary tidal marshes. More study is required to fully assess these potential impacts.

d) Recreation & Visual Resources

Two major impacts on recreation and visual resources would result from:

1) the partial flooding of the Grand Canyon of the Stikine which is considered to be a major national feature.

2) the construction of transmission lines following near to the route of Highway 37 which is designated as a "wilderness highway".

These impacts can only be partially compensated by providing access into previously inaccessible areas for recreation and viewing and by carefully locating and screening transmission lines.

e) Social

Major social impacts could result from the development because the projects are large, would require a large influx of construction workers, and are located in an isolated northern areas with a very small population and mainly subsistence lifestyles. The main issues that must be addressed prior to development are:

1. relations with native groups
2. protection of subsistence lifestyle
3. local employment and business opportunities
4. disturbances such as traffic, noise, dust, etc.
5. provision of adequate local services

f) Settlement

As the construction work force required would greatly exceed the local population and as the project sites are located some distance from the local villages, it is expected that new townsites would be required in addition to the normal single labour camps. At this time four townsites are envisaged; one near each of the proposed projects. One townsite would likely be retained after construction to house operations personnel. Further study and consultation with the local communities and Regional and Provincial Government agencies is required before the best settlement option could be determined.

IV. MITIGATION & COMPENSATION

B.C. Hydro is committed to minimizing adverse environmental and socio-economic impacts that could result from the Stikine-Iskut development. The preliminary project designs have already incorporated a number of mitigation changes which were identified in the studies completed to date. Examples are:

- provision of low level outlets to ensure downstream flows during initial filling,
- flow releases during reservoir filling higher than seasonal minimums to avoid impacts on fish downstream,
- restraints on power operation to minimize sudden changes in discharge to avoid impacts on fish.
- routing of transmission lines to avoid important wildlife habitat and areas of high visual value wherever possible.

A number of other mitigation and compensation measures have been identified and would be considered further when studies are resumed.

V. INTERNATIONAL ISSUE

Environmental impacts of the development on the Stikine Estuary in Alaska are not expected to be major. However, long term changes are possible in certain areas because of reduced flooding frequency and reduced sediment load in the river.

Relations with U.S. agencies have been cordial and while extensive discussions may be anticipated in future there appears to be no difficulty directly related to the Stikine-Iskut Development which would preclude agreement. It is expected that U.S. Government approval would be required in the light of present U.S.-Canada transboundary river practice. The difficulty to be faced in negotiations is that the direct benefits of the development would likely accrue only in Canada. Therefore, it may be necessary to demonstrate to the satisfaction of Alaska that the impacts are minor.

VI. DEVELOPMENT ALTERNATIVES

The Iskut projects could be constructed without the Stikine projects thus developing only 980 MW or 1/3 of the total proposed development. The unit cost of energy from the Iskut projects alone including the cost of transmission would be about 25% more than the unit cost of energy from the total development.

Development of the Iskut projects alone would result in considerably less environmental and social impacts because:

1) the Stikine River above the Iskut confluence would be unaffected and this section of the river contains the majority of known salmon habitat.

2) the flow changes in the estuary would be reduced to about 1/2 of that for the total development.

3) the Grand Canyon of the Stikine would not be affected.

4) the land flooded by reservoirs would be about 1/3 of that for the total development.

5) the local communities of Telegraph Creek, Dease Lake and Iskut Village would be largely unaffected.

The two Stikine projects could be developed alone (1920 MW or 2/3 the total development) and the unit cost of energy would be about the same as that for the total development. However, this partial development would retain most of the major environmental and social impacts of the total development.

STIKINE-ISKUT DEVELOPMENT
INTERIM ASSESSMENT REPORT

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SECTION 1.0 - INTRODUCTION

1.1 REPORT PURPOSE

The purpose of this report is to provide a summary description of the work undertaken to date on the Stikine-Iskut Development and to provide an interim assessment of the costs, benefits and environmental and socio-economic implications of the development.

Studies of the Stikine-Iskut development were undertaken by B.C. Hydro from 1977 to 1983 as part of Hydro's investigations of potential sources of electrical energy. In 1983, the studies were deferred as a result of a reduction in the forecast of the future demand for electrical energy from the Province of British Columbia. At that time, all work required for an application for an Energy Project Certificate under the B.C. Utilities Commission Act had not been completed. Hence this report can only present an interim assessment of the proposed development based on studies carried out to date. While the primary focus of this report is on the total development, which consists of projects in both the Stikine and Iskut basins, it also addresses the implications of limiting the development to those projects either on the Stikine River only or on the Iskut River only. This report also provides a record of all work completed and an outline of work still to be done before Hydro could make an application for government approval.

The report has been laid out as follows. Section 1 provides a general introduction to the report and sets out the geographic and procedural framework surrounding the studies. Section 2 provides details of the studies and activities undertaken, starting with the initial consideration of the basin and leading to recent studies of the impacts of the selected development. Section 3 provides a description of the potential development selected, and Section 4 assesses the energy benefits which would result. Section 5 provides an assessment of the environmental and social impacts of the development. Section 6 deals with features which have been incorporated or which could be incorporated to reduce the environmental impacts of this development. Alternative development scenarios and the impacts resulting from developing the Stikine sites only or the Iskut sites only are discussed in Section 7. Section 8 deals with the further work that could be required on the resumption of studies to prepare an application for an Energy Project Certificate. Figures and Tables will be found at the end of each chapter.

1.2 DOCUMENTATION

During the course of the studies, extensive documentation was prepared covering all aspects of the development. Appendix A lists the reports produced. These reports together with associated material are held by the B.C. Hydro Engineering Group.

1.3 STUDY AREA

The area studied during the Stikine/Iskut Development investigations encompasses a large portion of northwestern British Columbia and part of Alaska (Fig. 1-1). It includes the Stikine River basin and the broad area between the basin and Hydro's existing 500 kV transmission line between Prince George, Smithers and Terrace.

The Stikine-Iskut Development consists of four generation projects located in the Stikine-Iskut basin and the transmission required to connect them to the existing grid as shown in Figure 1-1. The Stikine Canyon and Tanzilla generation projects are located on the Stikine River, approximately 75 and 40 km respectively upstream from Telegraph Creek. The Iskut Canyon and More Creek projects are situated in the Iskut River basin, the largest tributary of the Stikine River. The Forrest Kerr diversion dam would divert the Forrest Kerr Creek into More Creek. Each of the Stikine projects would have a generating capacity of 960 MW, while the Iskut Canyon and More Creek projects would have a capacity of 810 MW and 170 MW respectively. Total generating capacity for the development would be 2900 MW. Three 500 kV lines would connect the damsites to the existing transmission system at the Telkwa substation near Smithers and possibly at the Skeena substation near Terrace.

The Stikine River and its major upstream tributaries, the Spatsizi and Klappan rivers, rise on the southeast flank of the drainage basin in the Skeena Mountains, the source also for the Skeena, Nass and Finlay rivers. Other upstream tributary rivers, the Pitman and the McBride, rise in the Cassiar Mountains on the northern flank of the drainage basin (Fig. 1-2).

The Grand Canyon of the Stikine extends over a distance of about 90 km from the head of the canyon down to Telegraph Creek, which is 170 km upstream of the British Columbia/Alaska border. The Stikine River generation project area extends from the vicinity of the Tanzilla River confluence, upstream of which the two proposed damsites would be located within the Grand Canyon, to the McBride confluence which is approximately the upstream limit of the Stikine Canyon reservoir.

The Iskut River has its source northeast of the Kluachon Lake in the vicinity of Iskut village. The river flows through a chain of lakes comprised of Kluachon, Eddontenajon, Tatogga, Kinaskan and Natadesleen lakes before continuing on to the head of the Iskut Canyon at the Forrest Kerr Creek confluence, approximately 130 km from the source. From Iskut Canyon, in which the damsite is located and which is 4 to 5 km long, the river flows in a westerly course 80 km to the confluence with the Stikine River at a point approximately 11 km upstream from the British Columbia-Alaska border.

More Creek rises in the glaciers of the Coast Mountains to the west of the Iskut River and flows in a generally easterly direction 50 km to its confluence with the Iskut River. The confluence is approximately 40 km upstream from Iskut Canyon. The More Creek Canyon is approximately 1.5 km long, with its outlet just 1.5 km upstream of the Iskut River confluence. The damsite is located in the canyon.

Forrest Kerr Creek also originates in the Coast Mountain glaciers to the north and west of the Iskut River. The creek flows in a southeasterly direction over a distance of 30 km to its mouth at the head of the Iskut Canyon. Forrest Kerr Creek would be diverted towards More Creek by a low dam situated approximately 0.8 km downstream from the confluence of the north and south forks of Forrest Kerr Creek.

Total drainage areas of the Stikine River basin upstream of the head of the canyon, Telegraph Creek and the British Columbia/Alaska border are 18800 km^2 and 49700 km^2 respectively. Total drainage areas of the Iskut Basin are 6900 km^2, 890 km^2 and 283 km^2 for the Iskut Canyon, More Creek and Forrest Kerr Creek proejcts respectively.

Population centers adjacent to the generation projects are Dease Lake located about 40 km north of the Stikine Canyon Project; Telegraph Creek located about 40 km southwest of the Tanzilla Project; and the Iskut Village located about 140 km north of the Iskut Canyon Project. In addition there are small settlements, motels or lodge facilities at the north end of Eddontenajon Lake, at Tatogga Lake, at the outlet of Kinaskan Lake and a small Ministry of Highways camp at Bob Quinn Lake.

Principal road access into the generation project area is via Highway 37 from the port of Stewart or from the Terrace-Smithers area. Access into the development area can also be gained from the north via the Alaska Highway from its interconnection with Highway 37 just west of Watson Lake, Yukon Territory.

Railway access into the immediate Stikine development area would become available should the B.C. Railway Dease Lake extension be completed. Currently, only the trackless grade and bridges exist north of about latitude 50°20'N.

Historically, riverboats travelled up the Stikine River as far as Telegraph Creek under certain flow conditions. Thus, indirect access into the development area could also be obtained via this water route, with transfer to the Telegraph Creek - Dease Lake road and thence to Highway 37.

Access by air into the generation projects area can be made via the Dease Lake paved airstrip or via the Iskut Village gravel airstrip. Regular flights also stop at Bob Quinn Lake and Telegraph Creek.

The area studied between the Stikine basin and the existing 500 kV transmission system lies east of the Coast Mountains and includes portions of the Skeena and Hazelton Mountains, the Stikine and Nechanko Plateaux, and the Nass and Fraser Basins.

It is a complex area with extreme topographic variations, ranging from relatively flat plains and plateau to rugged mountains, steep valleys and river canyon. The southeastern portion consists of rugged, forested plateau with many large lakes.

1.4 HYDRO'S PLANNING PROCESS

The Stikine-Iskut Development studies were undertaken as part of B.C. Hydro's policy of identifying potential sources of energy to ensure that there will always be projects available to meet the increasing demand for electrical energy. Each year, or more frequently, Hydro prepares a forecast of the future demand from the Province of British Columbia for electrical energy. This forecast is for 20 years and shows what the demand for electrical energy is expected to be each year in that period. Hydro then subtracts from this forecast demand the energy it can produce from existing generation and transmission projects. The difference shows the amount of electrical energy that will need to be provided from new generation projects. Hydro then sets out a plan for developing new projects in sequence to meet this forecast demand for the next ten years. This sequence is the basis of the system plan. The system plan generally schedules the lowest unit energy cost projects first. However, the feasibility of getting a development in service on time is also a major consideration as is the environmental acceptability of a developments.

The system plan is reviewed each year and if appropriate changed to match the new electric load forecast. Changes may also be made to the system plan in the light of new information gained on specific developments.

The fact that the planned timing of projects varies from year to year with the new system plans, and that some projects may be dropped completely for environmental or cost reasons means that it may be necessary to study a number of projects at any one time. Further, as it takes many years to plan a new electrical power development and to bring it into production studies of any potential development must start well in advance of any forecast need. Fifteen years or more may be required between the start of studies of a hydroelectric development and first power from that development.

1.5 STUDY AND REVIEW PROCESS

1.5.1 GENERAL

It is likely that if an application for an Energy Project Certificate for the Stikine-Iskut Development were submitted, a public hearing would be held by the Utilities Commission to consider matters such as need for the development, engineering design, environmental impact and financial feasibility. To meet the requirements of the hearing, lengthy and detailed studies must be carried out prior to an application.

A recommended format for the studies leading to an application has been set out in the "Guide to the Energy Project Review Process" which was published by the Ministry of Energy, Mines and Petroleum Resources in January 1982. Fig. 1-2 shows the study format recommended by the guide. In addition, the Energy Project Coordinating Committee (E.P.C.C.) comprised of representatives of the Ministry of Energy, Mines and Petroleum Resources, the Ministry of Environment, and the Utilities Commission, has been created to provide a liaison with proponents throughout the study period and to provide an ongoing review of studies.

The recommended study format calls for the initial submission of a prospectus which describes the proposed development and sets out the preliminary studies which the proponent plans to undertake. Following completion of these studies, a Preliminary Planning Report is submitted to the E.P.C.C. This report sets out the findings of the studies completed to date and describes the further studies the proponent plans to undertake prior to submitting an application.

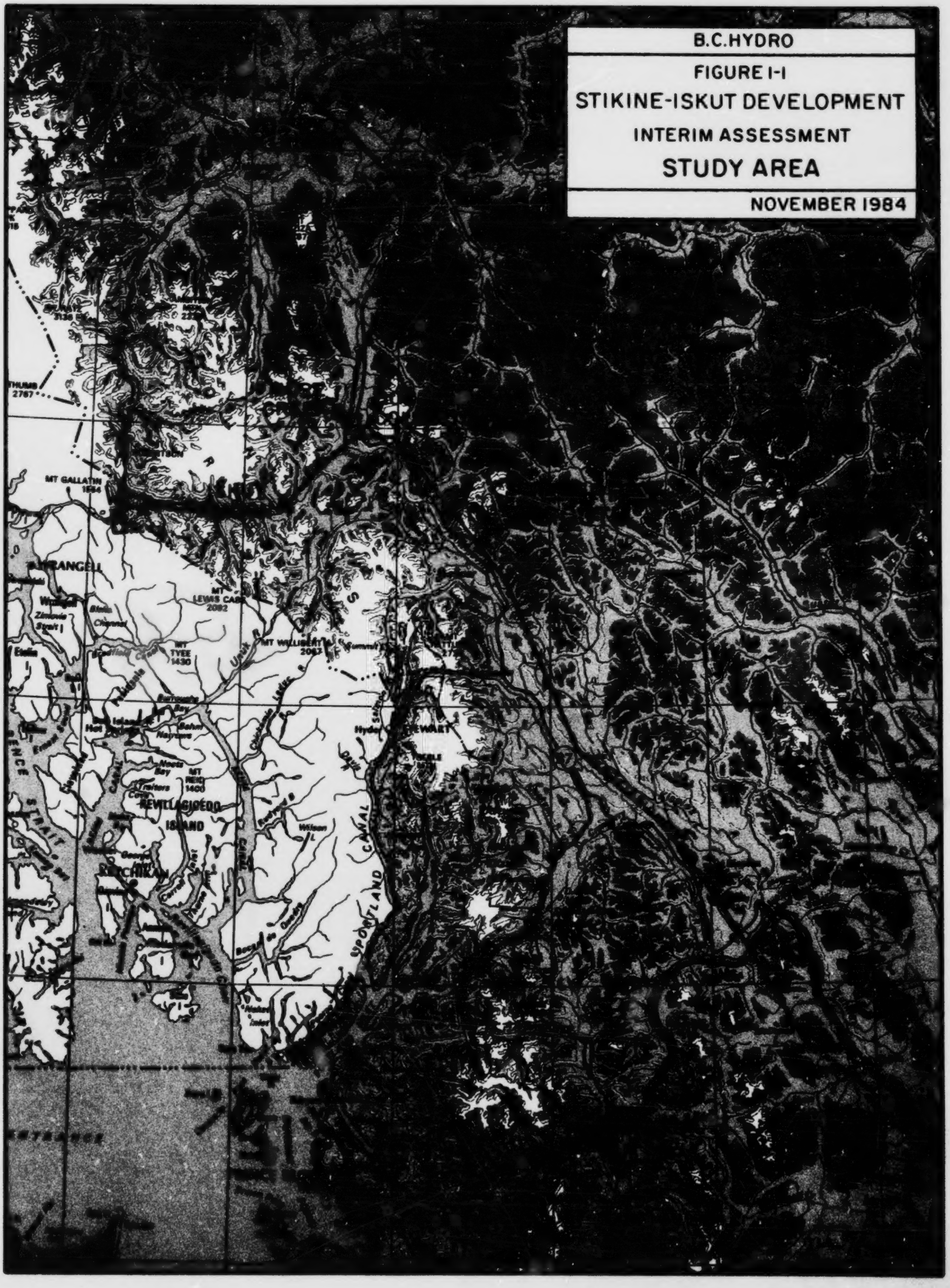
Hydro's studies of a potential hydroelectric development closely follow the format set out in the guide. However, the specific studies and their timing vary for the transmission and generation aspects of the development but can eventually lead to a common development application. In the case of the Stikine-Iskut Development, some studies were started prior to the Utilities Commission Act being passed or the guide published. Accordingly the initial studies followed the earlier format administered by the Environment and Land Use Committee Secretariat.

In considering a potential source of electrical energy Hydro usually carries out engineering and environmental overview studies before preparing a prospectus. These studies are usually conducted for both generation and transmission and are based on existing information and limited field inspection. The overview studies identify any major issues which might affect a project's acceptability as well as reporting generally on the engineering and environmental aspects. Costs of the development are also estimated. If the overview studies indicate that a project warrants further study and these studies are authorized by Hydro's board of Directors then studies are undertaken in accordance with the process set out in the guide.

1.5.2 APPLICATION

When sufficient information has been gathered in the course of the studies, an application for an Energy Project Certificate can be made.

However, in the case of the Stikine-Iskut Development, the reduction in the forecast demand for electrical energy has resulted in the suspension of preliminary design stage studies and the cancellation of detailed transmission studies. Accordingly, this interim report provides an assessment based only on the studies to date.


THUMB 2767
MT GALLATIN 1584
WRANGELL
MT LEWIS CASS 2082
MT TYEE 1430
MT WILLIBERT 2063
Hyder
STEWART
REVILLAGIGEDO ISLAND
KETCHIKAN
Wilson L
CANAL
STRAIT
ENTRANCE

B.C.HYDRO

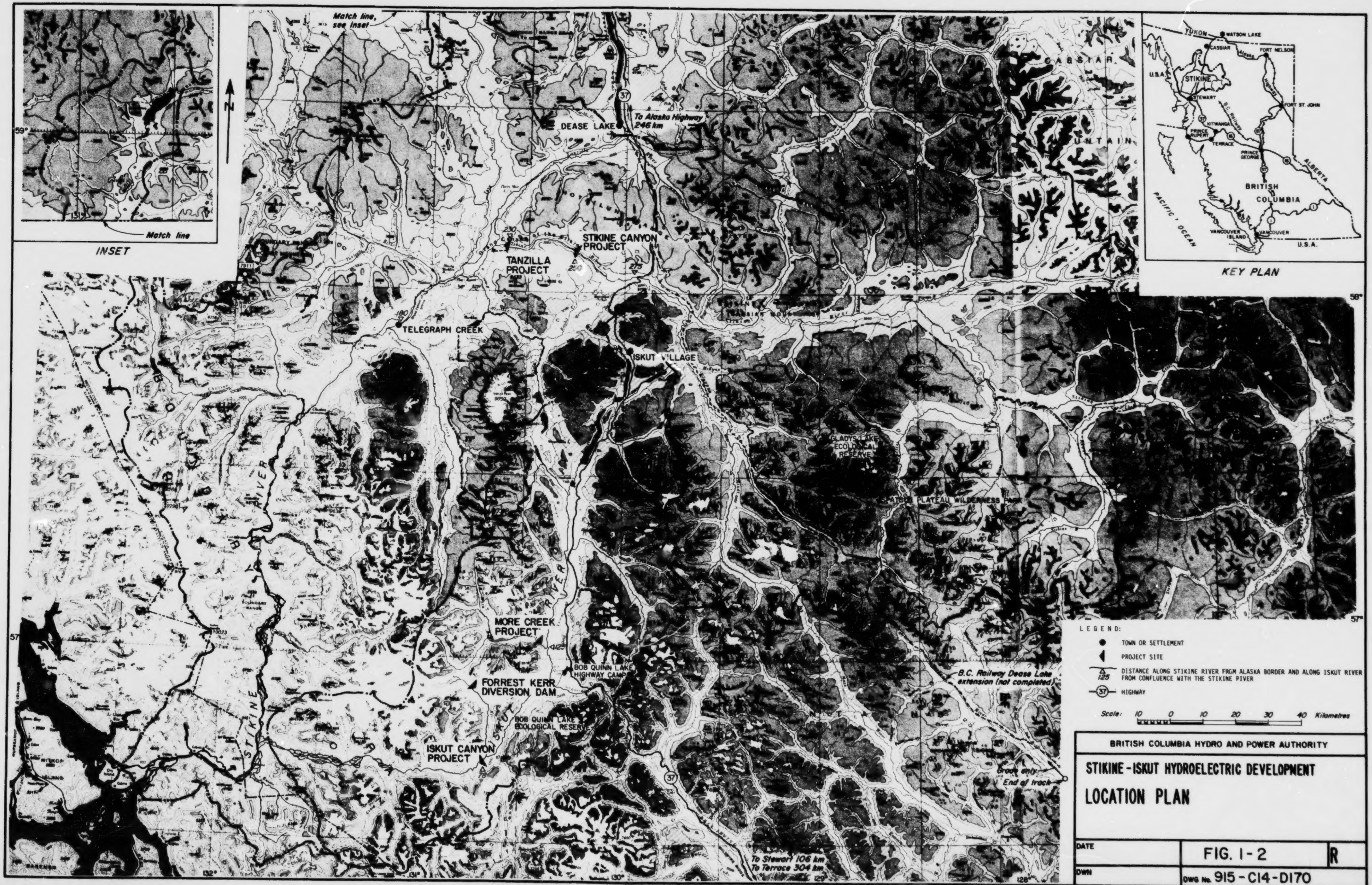
FIGURE I-I

STIKINE-ISKUT DEVELOPMENT

INTERIM ASSESSMENT

STUDY AREA

NOVEMBER 1984


Match line, see inset
INSET
59°
131°
Match line
N
DEASE LAKE
37
To Alaska Highway 246 km
CASSIAR
MOUNTAINS
230
TANZILLA PROJECT
STIKINE CANYON PROJECT
250
275
180
TELEGRAPH CREEK
ISKUT VILLAGE
58°
GLADYS LAKE ECOLOGICAL RESERVE
SPATSIZI PLATEAU WILDERNESS PARK
STIKINE RIVER
MORE CREEK PROJECT
125
BOB QUINN LAKE HIGHWAY CAMP
FORREST KERR DIVERSION DAM
BOB QUINN LAKE ECOLOGICAL RESERVE
ISKUT CANYON PROJECT
ISKUT RIVER
57°
B.C. Railway Dease Lake extension (not completed)
Grade only
End of track
To Stewart 106 km
To Terrace 304 km
132°
131°
130°
129°
128°
KEY PLAN
YUKON
WATSON LAKE
CASSIAR
FORT NELSON
U.S.A.
STIKINE
STEWART
FORT ST. JOHN
B.C. RAILWAY
KITWANGA
PRINCE RUPERT
TERRACE
PRINCE GEORGE
ALBERTA
BRITISH COLUMBIA
PACIFIC OCEAN
VANCOUVER ISLAND
VANCOUVER
U.S.A.
LEGEND:
● TOWN OR SETTLEMENT
PROJECT SITE
125 DISTANCE ALONG STIKINE RIVER FROM ALASKA BORDER AND ALONG ISKUT RIVER FROM CONFLUENCE WITH THE STIKINE RIVER
37 HIGHWAY
Scale: 10 0 10 20 30 40 Kilometres

BRITISH COLUMBIA HYDRO AND POWER AUTHORITY

STIKINE - ISKUT HYDROELECTRIC DEVELOPMENT

LOCATION PLAN

DATE	FIG. 1 - 2	R
DWN	DWG No. 915 - C14 - D170	

Figure 1-3

Energy Project Application Process

PRE-APPLICATION PHASE

PROSPECTUS

(1) General project description and schedule.
(2) Project rationale.
(3) Description of proposed preliminary studies.

Review by Energy Project Coordinating Committee and Working Committees;
consultation with proponent

PRELIMINARY PLANNING REPORT

(1) Identification and assessment of feasible alternative locations.
(2) Analysis of alternative locations and identification of preferences.
(3) Preliminary Procurement Plan.
(4) Terms of reference for proposed environmental/socio-economic impact studies.
(5) Terms of reference for proposed project justification studies.
(6) Description of public consultation program.
(7) Preliminary list of approvals, licences, and permits required.

Review by Energy Project Coordinating Committee and Working Committees;
consultation with proponent in developing Application

APPLICATION PHASE

APPLICATION

(1) Description of applicant as per Regulation.
(2) Project description:
    (a) purpose, costs, and ancillary facilities.
    (b) timetable for construction, operation, abandonment, reclamation, with critical dates.
    (c) public works, undertakings, or infrastructure entailed with costs and schedule.
(3) Environmental and socio-economic impact assessment and proposals for minimizing negative impacts and maximizing positive impacts.
(4) Project justification: energy supply/demand, technical feasibility, financial feasibility, procurement, benefit-cost data.
(5) Ancillary applications: approvals, permits, licences required under *Pollution Control Act, Water Act*, and other pertinent statutes.
(6) Public consultation program description and summary of response.
(7) Other information as required.

Review by Energy Project Coordinating Committee and Working Committees;
consultation with applicant as necessary

APPLICATION DISPOSITION BY MINISTER(S)

[Section 19(1) of *Utilities Commission Act*]

SECTION 2.0 - STUDIES BACKGROUND

2.1 GENERATION STUDIES

2.1.1 OVERVIEW AND EARLIER STUDIES

Hydroelectric development of the Stikine basin was studied in 1964 and 1965 by the British Columbia Department of Lands, Forests and Water Resources. Further studies were carried out by consultants on behalf of B.C. Hydro during 1965 and 1966. During these initial studies ten potential generation sites were identified on the Stikine River of which five were recommended for further study. On the Iskut River nine sites were identified of which three were recommended for further study.

In 1971 and 1972 the British Columbia Energy Board carried out an extensive study of the hydroelectric potential of the province as a whole. As part of this study, the hydroelectric potential of the Stikine basin was again investigated. The Board's report described a development plan for the Stikine River involving the construction of five dams, three in the Grand Canyon of the Stikine and two further downstream. A two dam development for the Iskut River was described with one dam in the Iskut Canyon some 60 km upstream of the Iskut/Stikine confluence and another dam a further 110 km upstream on the Iskut River near the outlet of Kinaskan Lake.

Hydroelectric development of the Stikine and Iskut rivers has also attracted the interest of private groups. Studies of the Iskut Canyon site were carried in 1964 and 1965 by G.E. Crippen and Associates Ltd. on behalf of Iskut Pulpower Ltd. In 1971 Crippen, on behalf of Brinco Ltd. studied a development plan of the Iskut river which combined the Iskut Canyon damsite with an upstream damsite on More Creek, a tributary of the Iskut.

B.C. Hydro's present program of engineering and environmental studies commenced with overview studies in 1977. The overview engineering studies concentrated on determining the optimum development plan for each river and at an overview level of detail, the technical and economic feasibility of the selected plan.

The overview environmental studies concentrated on obtaining and reviewing existing information on the development area. Brief visits were also made to the development area. Sufficient information was obtained by these two methods to determine significant potential impacts and to permit comparison of the environmental implications of each alternative.

Two alternatives were considered for each river. On the Stikine, the 1972 Energy Board plan for three damsites in the Grand Canyon was examined as was a two dam arrangement. The capacity and energy capability of the two plans were found to be the same. However, the two dam plan was recommended for further study as it was estimated to have a significantly lower capital cost and less environmental impacts than the three dam scheme. The 1972 Energy Board report also described two potential damsites downstream from the canyon. These were re-examined by B.C. Hydro but further study was not recommended as development costs were estimated to be relatively high and salmon runs would be blocked.

On the Iskut River one of the plans considered was the B.C. Energy Board plan with the two sites on the Iskut, one in Iskut Canyon and one 110 km upstream. The other plan considered was that with the upstream damsite located on More Creek. The latter plan was recommended for further study because of lower development costs and lesser environmental implications.

The overview studies indicated that hydroelectric development of the Stikine and Iskut rivers would be technically feasible and economically attractive.

2.1.2 ENGINEERING FEASIBILITY STUDIES

Engineering feasibility studies were started in 1978 on the completion of the overview studies and examined in detail the development plans and damsites recommended by the overview studies. Foundation investigations were carried out at each of the proposed damsites other than Forrest Kerr Creek. Using the information from these investigations, dam axes were located and alternative layouts were prepared and costed. In addition, construction material investigations, including sampling and laboratory testing, were undertaken. New topographic mapping including associated control and engineering surveys was prepared. Reservoir shoreline stability studies were undertaken as were power studies to determine the energy potential of the various arrangements and alternative developments being studied. The feasibility studies were completed in early 1980.

The field work for the feasibility studies was undertaken during the 1978 and 1979 summer seasons and details of the investigations undertaken are shown in Tables 2-1A and 2-1B.

Further details of the engineering feasibility studies may be found in the report titled "Stikine-Iskut Hydroelectric Development Feasibility Study" Report No. H1163 by B.C. Hydro's Hydroelectric Generation Projects Division. This report details the work that was carried out and describes the design of the development based on the information obtained from the feasibility studies. Alternate designs considered are also described.

2.1.3 ENGINEERING PRELIMINARY DESIGN STUDIES

Preliminary design studies were started in 1980. The decision to commence this stage of the studies was based on the findings of the feasibility studies which confirmed the overview finding that the development was technically feasible and economically attractive.

The overall purpose of the preliminary design studies was an extensive foundation investigation program undertaken with the objective of confirming or modifying the layouts proposed in the feasibility studies. The preliminary design studies also included further geological mapping and more extensive hydrological and hydraulic studies. Work on the reservoir slope stability studies which was started at the feasibility level was continued. In addition, further work was undertaken on arch dam design and on the design of site facilities. Also further materials investigations were undertaken.

The investigations undertaken from 1980 to 1983 inclusive are detailed in Tables 2-1A and 2-1B.

Because of budgetary restraint, the study programs at all four projects were restricted in 1983 to mapping and recording activities and completing the pump tests in the lava flats area of the Iskut Canyon Project.

2.1.4 ENGINEERING STUDY FINDINGS

The principal findings of the field and office investigations of the Stikine River projects are as follows:

1. The optimum hydroelectric development of the Stikine River would consist of a dam and a powerplant at both the Stikine Canyon Project and Tanzilla Project sites. The upstream Stikine Canyon Project reservoir would regulate the flow for both projects and the Tanzilla Project would therefore be operated as a run-of-river plant.

   The overall construction period from award of first contract to first in-service date is estimated to be 7 3/4 years for the Stikine Canyon Project and 6 1/4 years for the Tanzilla Project.

2. At the Stikine Canyon Project site, enough investigations have been carried out to conclude that the geological conditions will be generally excellent for foundations and excavations of the project structures.

3. A similar conclusion can be drawn about the geological conditions at the Tanzilla Project powerhouse and power tunnel sites. However at the damsite, although conditions appear favourable for a fill dam, insufficient investigations have been undertaken to comment on the adequacy of the site for an arch dam.

4. Based on 1983 economic parameters, the power and optimization studies have confirmed selection of a maximum normal reservoir level of El. 794 for the Stikine Canyon Reservoir. These studies indicate that the optimum maximum reservoir drawdown should be 55 m. The proposed 960 MW of installed capacity is indicated to be appropriate for this maximum reservoir drawdown.

5. On the basis described above, the proposed installed capacity of 960 MW would be appropriate for the run-of-river Tanzilla Project.

6. Construction material investigations have indicated that sufficient materials are available for construction of the projects. Further investigations are required to further define material properties and to delineate boundaries of preferred borrow pit areas.

7. Reservoir shoreline studies have identified three areas of the Stikine Canyon reservoir where reservoir impoundment and operation could cause marked slope instability. Further investigations are required to allow a reasonable prediction of probability and mode of potential slope failure at these locations.

The principal findings of the field and office investigations into the Iskut Projects are as follows:

1. The optimum hydroelectric development of the Iskut River basin would have a dam and powerplant in the Iskut Canyon, a dam and powerplant in the More Creek Canyon and a diversion dam at the headwaters of Forrest Kerr Creek. The optimum Iskut Canyon project depends on flow regulation provided by the proposed upstream More Creek reservoir.

2. The foundation rock in the "C" Reach of the Iskut Canyon would provide competent foundations for any conventional dam type.

   However, due to uncertainties concerning possible differential movements along shears in the foundation rock resulting from seismic activity, an embankment dam has been featured in this report, even though it would be more costly than a concrete arch dam. Although no evidence of post-glacial movement on the northeasterly trending shears in the "C" reach of Canyon has been found, further investigations of these shears and the associated Forrest Kerr fault including a seismic risk analysis is required before a final choice of dam type can be made.

3. The seepage around the Iskut Canyon damsite should be controlled by a three-line grout curtain across the north and middle channels of the Lava Flats. However, further investigations, testing and analysis are required to better define the seepage control requirements and to estimate the probable seepage losses.

4. There is evidence that several lava flows have occurred in the lava flats area south of Iskut Canyon over the last 9000 years. The potential for future volcanic activity in this area presents some risk to the proposed Iskut Canyon Project. Further investigations and analysis should therefore be undertaken, preferably before recommencing other preliminary design studies, in order to assess this risk.

5. Based on limited site exploration, the damsite in More Creek Canyon would be suitable for any conventional type of dam. However, additional exploration and project arrangement studies would be required before the optimum type can be selected.

6. Construction material investigations have indicated that sufficient materials are available to construct any of the alternative arrangements for both projects. Further studies of the materials in Areas 2, 7, 4 and 4A are required to further define material properties and quantities and to determine the best source.

7. Reservoir shoreline studies have identified potential areas where reservoir impoundment and operation could cause sliding or slumping. Further investigations in these areas are required to define the risk to the projects.

8. Scheduling studies for the featured arrangement have indicated that the construction periods from first contract award on 1 January of Year 1 to first in-service date would be 6-3/4 years for the Iskut Canyon Project and 5-3/4 years for the More Creek Project.

2.1.5 ENVIRONMENTAL STUDIES

Environmental feasibility studies were started in 1978 and in that year fisheries studies downstream of the proposed reservoir areas were undertaken. A study of the mountain goats in the Stikine Canyon was also started, as was a bibliographic study of the estuary in Alaska. In 1979, fisheries studies were continued and field work in the estuary was undertaken. Wildlife, recreation and the scenic values of the Stikine Canyon were also studied.

In 1980 the feasibility studies report concluded that although the development raised a number of environmental issues which would require resolution, none appeared to preclude continued study of the development.

The fisheries studies indicated that without mitigation overall effects on salmon would be adverse but that mitigation measures might be expected to maintain fish runs at their present level.

The detailed environmental studies were started in 1980. These were designed as a structural continuation of previous work and concentrated on the collection of both physical and biological data to allow a comprehensive assessment of impacts to be made. A wide range of studies including fisheries, estuary wildlife, recreation and forestry were continued during 1981. In addition studies of agriculture, socio-economic and resource evaluation were commenced.

In 1982, a number of environmental reports were completed in draft and, together with previously completed reports, these were forwarded to the E.P.C.C. in Victoria for review. Reports were also sent to relevant government agencies in Alaska and those dealing with fisheries issues were forwarded to the Canadian Department of Fisheries and Oceans. Additional hydrologic studies were undertaken in 1982 including downstream temperature modelling, reservoir modelling and suspended sediment studies. Other studies undertaken included a land use study and a biophysical mapping program which was undertaken in conjunction with the Ministry of Environment.

Environmental studies in 1983 were limited due to growing uncertainty about future provincial energy needs. However, the biophysical mapping was completed as was the land use study. Further fisheries and hydrological work was undertaken together with further archaeological studies.

2.1.6 INTERACTIVE STUDIES

During the course of the overview and feasibility studies, those engaged engineering environmental study teams worked closely together and were apprised of each others findings on an ongoing basis. Amendments were made to planned studies and project features on the basis of the findings of the other study group.

During the preliminary design studies this interaction was taken a step further and procedures were introduced to refine the proposed development and to incorporate in the design those features that would mitigate environmental impacts at acceptable cost. The procedures set up involved the provision of a description of the development by the engineering studies team to those involved in the environmental studies. They in turn provided to the engineering study team details of the environmental impacts caused by the described project. In the light of these impacts, the engineering team revised the described development and returned it to the environmental study team. It was intended that this iterative process would go through a number of cycles and would lead ultimately to a project suitable for licencing. However, the process was curtailed by the suspension of the studies. Accordingly, the development described in this report is only partially refined and it is intended that the iterative process will be restarted on the resumption of studies.

2.1.7 GOVERNMENT CONSULTATION

Studies by Hydro of potential developments serve a number of purposes. One is to provide information on which Hydro may decide if further studies and ultimately construction are justified. Another is to provide the information required by the review and regulatory agencies so that if an application for approval is made, there is sufficient information on which to base a decision.

Hydro's overview studies of the Stikine-Iskut development were directed to the first objective only, i.e. providing information to Hydro. Nevertheless, throughout the studies, there was extensive informal contact with government agencies who provided much of the information on which the studies were based.

Liaison with government agencies was initiated in 1978 with the start of feasibility studies and a meeting was held under the auspices of the Environment and Land Use Committee Secretariat in June of that year.

This meeting was attended by Hydro representatives and by representatives of government agencies. At this meeting, the development, Hydro's study plans and interaction between Hydro and the government agencies were discussed. Later in 1978 Hydro forwarded comprehensive draft terms of reference for its studies to the ELUC Secretariat for review by them and by the agencies. In January 1979, a further meeting was held with the agencies under ELUC auspices. This meeting discussed the planned studies and work underway. Government comments on the terms of reference for Hydro's studies were received by Hydro in early 1979.

The ELUC Secretariat was disbanded in 1979 and subsequently the Utilities Commission Act received Royal Assent in August 1980. The review procedure previously undertaken by the ELUC Secretariat was assigned to the new Energy Project Coordinating Committee chaired by the Director of the Project Analysis Branch of the Ministry of Energy, Mines and Petroleum Resources.

Since the formation of the Energy Project Coordinating Committee Hydro's staff engaged on the Stikine-Iskut development maintained an ongoing liaison with this committee. In 1982, a number of preliminary environmental reports were submitted to the E.P.C.C. for a review by them and by the government agencies. In view of the fact that a preliminary planning report had not been prepared, a summary document was submitted with the preliminary environmental reports.

Throughout the studies, Hydro has had to seek permission to carry out aspects of its investigations program. These permissions have been sought from a number of ministries including the Ministry of Lands, Parks and Housing, the Ministry of Forests, and the Heritage Conservation Branch.

Also throughout the studies, the Federal Department of Fisheries and Oceans has been kept apprised of Hydro's fisheries studies and their comments have been sought on terms of reference and reports.

Contact between the B.C. Hydro study team and Alaskan government agencies was initiated in 1979 on an informal basis. In 1982 a formal commitment to share information on the Stikine-Iskut development and related matters was made when the B.C.-Alaskan Information Exchange agreement was signed by the Premier of B.C. and the Governor of Alaska. Since 1982 the committee formed by this agreement has met a number of times and has acted as the focus for the exchange of information on work being done on the Stikine by B.C. Hydro and the Alaskan agencies.

2.2 TRANSMISSION STUDIES

2.2.1 OVERVIEW STUDIES

The required transmission was studied and costed as part of the 1977 overview studies. This study was carried out by Hydro staff and was general in nature. Between June 1978 and December 1979, Ian Hayward and Associates conducted a study of possible transmission corridors to link potential damsites on the Stikine, Iskut and Liard Rivers with the existing transmission grid and lower mainland areas.

The purpose of these studies which were referred to as the Northern Transmission Studies was to map constraints to transmission line construction, identify feasible corridors for the lines and highlight possible issues related to the transmission line development.

The consultant's report on the Northern Transmission Studies was used by Hydro to set the stage for preliminary investigations of feasible transmission corridors between the Stikine-Iskut damsites and the existing 500kV transmission grid.

2.2.2 PRELIMINARY PLANNING STUDIES

Preliminary planning studies for the transmission component of the Stikine-Iskut development were conducted between April 1980 and July 1982. They consisted of the following studies:

1. system planning studies which determined the transmission voltage and number of lines required as well as the electrical implications of connecting into the various possible stations in the grid;

2. route engineering studies which identified and evaluated technically feasible corridors for the required number of transmission lines between the generation sites and the possible substations;

3. environmental studies which assessed the potential environmental impacts that could be associated with construction and operation of transmission lines along the feasible corridors.

The studies were initiated under the ELUC Guidelines for Linear Development (March 1977) but are considered to comply with the spirit of the March 1980 Utilities Commission Act and the preliminary planning stage of study described in the January 1982 "Guide to the Energy Review Process."

Three reports documenting the studies were released by Hydro in January 1983 and were widely distributed in the study area and to local and provincial governments. These reports were "Preliminary Environmental and Social Impact Assessment of the Stikine-Iskut Transmission System", Ian Hayward & Associates, July 1982, which documented the environmental studies; "Preliminary Route Engineering Assessment of the Stikine-Iskut Transmission System," B.C. Hydro Transmission Projects, Division, October 1982, which documented the route engineering studies; and the "Preliminary Planning Report for the Stikine-Iskut Transmission System," B.C. Hydro System Engineering Division, December 1982", which summarized all the preliminary transmission studies, presented preferred corridors for route selection studies and outlined the public consultation program to follow.

Hydro concluded in the Preliminary Planning Report that three 500 kV lines would be required to transmit energy from the proposed hydroelectric generation sites on the Stikine and Iskut rivers to the provincial electric system. It was proposed that these transmission lines connect to the grid at the Telkwa substation near Smithers and possibly at the Skeena Substation near Terrace. Fig. 2-1 shows the corridors recommended for detailed route selection studies based on the preliminary planning studies.

The studies also showed that reinforcement to the transmission system south of the Terrace, Smithers and Prince George Area would be required if both the Iskut and Stikine rivers were developed as proposed. Because of uncertainties as to the timing of other projects and the location and magnitude of new loads, the specific requirements for system reinforcement were and continue to be uncertain.

2.2.3 DETAILED ROUTE SELECTION STUDIES

In late 1982 and in early 1983 Hydro undertook the initial work required for detailed route selection studies. This entailed detailed office study of the 1:50,000 topographic maps together with interpretation from aerial photography. In some difficult areas, a digital terrain model of the area was produced. Due to the project deferrment only a limited field program was carried out consisting of aerial reconnaissance of the route, suggested by the above office studies. Winter wildlife surveys were conducted during January and March of 1983 along the corridors recommended for further study in the Preliminary Planning Report. Draft Terms of Reference for detailed environmental studies were submitted to the government agencies for comment prior to being finalized. A coordinating consultant was appointed and specialist study team selected with field work planned to begin in early June 1983. The detailed studies were halted before any major field work was conducted due to a projected delay in the need for the Stikine-Iskut Development.

The interim assessment of the proposed development provided by this report was subsequently authorized. This entailed evaluation of a preliminary technically preferred route shown in Fig. 1-1. Limited field work was conducted by Hydro environmental specialists in the late summer of 1983 to facilitate the evaluation of the route.

2.2.4 GOVERNMENT CONSULTATION

Consultation with the provincial government on the Northern Transmission Studies, which included the Liard and the Stikine-Iskut developments, was initiated at a meeting in early 1980 between Hydro, the Environment and Land Use Committee (ELUC) secretariat and provincial government agencies. At this meeting Hydro indicated their general study intentions and provided study area and preliminary project descriptions. A copy of the Northern Transmission Overview Study Report was sent to ELUC in March 1980 for information. In July 1980 the Northern Transmission Prospectus was released to the public and submitted to ELUC for distribution to provincial government agencies. The Prospectus described the corridor selection studies that Hydro intended to carry out and contained general terms of references for the preliminary planning stage environmental studies. The prospectus and terms of reference were reviewed by the agencies and ELUC submitted comments to Hydro. Hydro and the environmental study team coordinating consultant met with ELUC in early July 1980 to discuss ELUC involvement in the Stage I environmental studies, and to pave the way for specialist consultant contact with the regional provincial agencies appropriate to their study disciplines. Consultation with the agencies was largely discipline study specific up to completion of the preliminary planning stage.

Following Royal Assent to the Utilities Commission Act in August 1980, there was substantial contact between Hydro and the Ministry of Energy to discuss implications of the Act on development studies that were underway, such as the Northern Transmission Studies. On 29 November 1982, as the Stikine-Iskut Transmission Preliminary Planning Reports neared completion, a meeting was held with the EPCC and government agencies to present the status of the Stikine-Iskut development studies and discuss plans for distribution of the transmission preliminary planning reports. The reports were subsequently transmitted to the EPCC in January, 1983, and distributed to the agencies in mid-February. Agency comments on the reports were received by Hydro in early June, 1983.

Terms of reference for wildlife studies were submitted to the Ministry of of Environment in December 1982 to facilitate the winter wildlife survey of the preferred transmission corridor. The terms of reference were reviewed and discussed with Victoria and regional provincial government staff. Draft detailed route selection study terms of reference were submitted to the EPCC in early March, 1983 and agency comments on the Terms of Reference were received by Hydro in May, 1983. Several meetings were held in May-June, 1983 between Hydro, the environment coordinating consultant, environmental study team members and the Ministry of Environment to discuss specific discipline study programs.

On 22 June 1983, shortly after deferral of the Stikine-Iskut detailed route selection studies, a meeting was held with Hydro and the EPCC to discuss development study wind-down and to conclude corridor selection, thereby wrapping up the preliminary study phase for the transmission component of the development. At this meeting the E.P.C.C. agreed with Hydro's preference for the Highway 37 corridor subject to Hydro reconsidering its choice on the resumption of studies in the light of changed circumstances.

2.3 PUBLIC INFORMATION/CONSULTATION PROGRAM

2.3.1 INTRODUCTION

This section provides a brief summary of the public information/ consultation program conducted by B.C. Hydro as part of the Stikine-Iskut generation and transmission investigation. It also includes an evaluation of the program and an outline of future activities should the project investigations be reactivated at some future date.

2.3.2 PROJECT STUDY AREA

The area covered by the transmission and generation studies is large and remote, including most of northwestern British Columbia. Communities in closest proximity to the generation projects are Dease Lake, Telegraph

Creek, Iskut, and Cassiar, plus the Alaskan Communities of Wrangell and Petersburg. The study area for the transmission system extends from the generating sites south to Terrace and Smithers, and southeast to Prince George.

The northern parts of the study area are lightly settled and communications are poor with little radio, television or regular newspaper service. Much of the population in this area is of native origin.

2.3.3 PURPOSE AND OBJECTIVES

In general the purpose of Hydro's public information and consultation program was to ensure that any group or individual affected by, interested in, or concerned about the project was:

(a) informed about plans at an early stage;

(b) aware of the planning and decision-making process;

(c) provided with information on the project and its potential impacts; and

(d) provided with opportunities to consult with members of the project planning team before final decisions are made.

The objectives of the public information and consultation program were:

(a) to enable Hydro to make more informed and responsive decisions;

(b) to arrive at the end of the planning process with no "surprises" for either Hydro or the public; and

(c) to identify and resolve as many problems as possible prior to formal Utility Commission hearings for project approval.

The public information and consultation program was also intended to meet the requirements of the Utilities Commission Act, introduced in 1980. It should be noted, however, that the program was initiated prior to the promulgation of the Act in 1980, and the issuance of the "Guide to The Energy Project Review Process" in 1982.

2.3.4 ORGANIZATION

The planning and implementation of the information/consultation program was the responsibility of the Community Relations Department.

Initially Community Relations assigned one staff member to both the transmission studies and the generation studies on a part-time basis. In 1982, a third staff member, located in Whitehorse, was employed to undertake field activities for both the Liard and Stikine-Iskut projects.

2.3.5 PARTICIPANTS

The public information/consultation program involved the following groups:

(a) B.C. Hydro's North Coast regional staff;

(b) Regional District elected officials and staff;

(c) MLA's and MP's;

(d) Municipal elected officials and staff;

(e) Staff of provincial and federal agencies;

(f) Indian bands and tribal councils;

(g) Local media;

(h) Trappers, Guides and Outfitters;

(i) Citizen and resident's interest groups;

(j) Individuals.

2.3.6 PUBLISHED INFORMATION

In addition to periodic news releases, reports and other publications used in the information/consultation program are listed below:

1979 - Stikine-Iskut rivers, Public Information Bulletin January 1979.

- Forest Impact Study, Stikine-Iskut Environmental Studies, Preliminary Report. (Forestal International Ltd.) December 1979.

1980 - Preliminary Archaeological Study of the Proposed Stikine-Iskut Hydroelectric Development. (Aresco Ltd.) April 1980.

- Stikine-Iskut Fisheries Studies 1979, Preliminary Report. (P. McCart Biological Consultants Ltd.) April 1980.
- Prospectus, Northern Transmission Studies, Electrical Energy Transmission from Potential Hydroelectric Generation Projects on the Stikine-Iskut and Liard rivers, July 1980.
- Stikine-Iskut Hydroelectric Development Progress Report on Feasibility Studies, December 1980.
- Stikine-Iskut Rivers Hydroelectric Project Environmental Studies, Economic Geology, Preliminary Report. (B.C. Hydro System Engineering Division, Generation Planning Department.) December 1980.

1981 - Caribou Survey Data and Snow Depth in Vicinity of Spatsizi Plateau, 1980, Preliminary report (B.C. Hydro, Engineering Services Division, Environmental and Socio-Economic Services Department) March 1981.

- Studies on Fur Bearing Mammals in the Stikine River Drainages, Preliminary Report. (McCourt Management Ltd.) April 1981.

- Preliminary Analysis of the Potential Impact of Hydroelectric Development of the Stikine River System on Biological Resources of the Stikine Estuary. (Beak Consultants Ltd.) September 1981.

- Stikine-Iskut Hydroelectric Development Feasibility Study: Hydrology, River Regime and Morphology, Preliminary Report. (B.C. Hydro, Hydroelectric Generation Projects Division.) October 1981.

- Stikine-Iskut Hydroelectric Development Exploration Program and Access Requirements, December 1981.

1982 - Northern Projects Journal, February/May/November.

- Stikine-Iskut Hydroelectric Development - Environmental Studies in Alaska - October 1982.

- Stikine-Iskut Development, Status Report, October 1982.

- Preliminary Planning Report for the Stikine-Iskut Transmission System, October 1982.

- Preliminary Route Assessment of the Stikine-Iskut Transmission System, October 1982.

- Preliminary Environmental and Social Impact Assessment of the Stikine-Iskut Transmission System (Ian Hayward and Associates), June 1982.

1983 - Northern Projects Journal - April

- Quick Facts about B.C. Hydro's Proposed Stikine-Iskut Hydroelectric Development.

- Stikine-Iskut Transmission Project, Terms of Reference, Environmental and Socio-Economic Studies.

2.3.7 INFORMATION/CONSULTATION PROGRAM 1978-1983

Initial public notification of the Stikine-Iskut investigation program for power development by B.C. Hydro was by means of news releases in 1978 followed by an Information Bulletin in late 1979. Beginning in 1980, the first informal meetings were held with local government officials, MLA's, Indian bands, and public groups in Terrace and Dease Lake. Additional meetings were arranged between 1981 and 1983. Meetings with public groups were held in Alaska in 1980, 1981 and 1982.

Informal meetings included the Tahltan, Nishga and Gitskan-Carrier tribal organizations, Regional District of Kitimat-Stikine, municipal councils in Terrace, Hazelton, New Hazelton, Smithers and Telkwa, as well as various citizen groups such as the Telkwa Foundation, Residents for a Free Flowing Stikine, Friends of the Stikine, Save the Bulkley, and the Kispiox Community Association. Hydro staff also participated in the annual meetings of the Northwest Media Association in 1982 and 1983.

During 1982 site tours were conducted for media representatives as well as for staff members of provincial government resource ministries. Also in 1982 representatives of the Association of United Tahltans were brought to Vancouver for meetings with senior Hydro staff.

2.3.8 KEY PROBLEMS

The following is an outline of the main problems that affected the implementation of the information/consultation program:

1. Size and remoteness of the study area, coupled with a lack of communications facilities and travel amenities.

2. Insistence by some Native Indian groups that their rights be recognized before they will participate in any development planning process.

3. A perceived lack of direct local benefits and employment opportunities arising from the study program, and from subsequent construction and operation of the project (including local power supply).

4. Resentment felt by local residents towards interference by "outsiders".

5. Public scepticism about project justification (e.g. load forecasting and power exports).

6. Lack of local public trust in Hydro's environmental assessment program.

7. Local residents' misunderstanding of B.C. Hydro's relationship to the provincial government and dissatisfaction with the provincial governments' energy project approval process.

9. Wilderness values associated with the project area.

2.3.9 EVALUATION

During its early stages of planning, the public information/consultation program did not meet its objectives owing to inadequate staff resources and information availability, and to lack of recognition by Hydro of the extent of the communications and travel problems in the study area. As a result public misunderstandings and resentments were created that might have been avoided. Hydro's initial reliance upon news releases and brief Information Bulletins in a region where newspapers and radio were virtually nonexistent were no substitute for early personal contact with local residents.

In 1981 increased staff resources, a stepped up program of meetings with public groups, and improved availability of information began to improve the situation, but a high level of local public resentment remained. In 1982, the introduction of the Northern Projects Journal mailed to every household in northern B.C. was a significant improvement in information distribution. By late 1982 growing uncertainties about project timing, and extended delays in completion of key studies began to interfere with continuity of field contact.

While information availability and public dialogue improved significantly late in the study program, "consultation" in the sense of the project team receiving and considering in depth informed advice and comment from the public, never really began.

2.3.10 FUTURE PROGRAM

It is intended that when studies of the Stikine-Iskut Development are restarted, a program as outlined below, would be undertaken to avoid the problems identified above and better achieve information/consultation objectives:

1. A clear strategy and program plan would be developed and implemented.

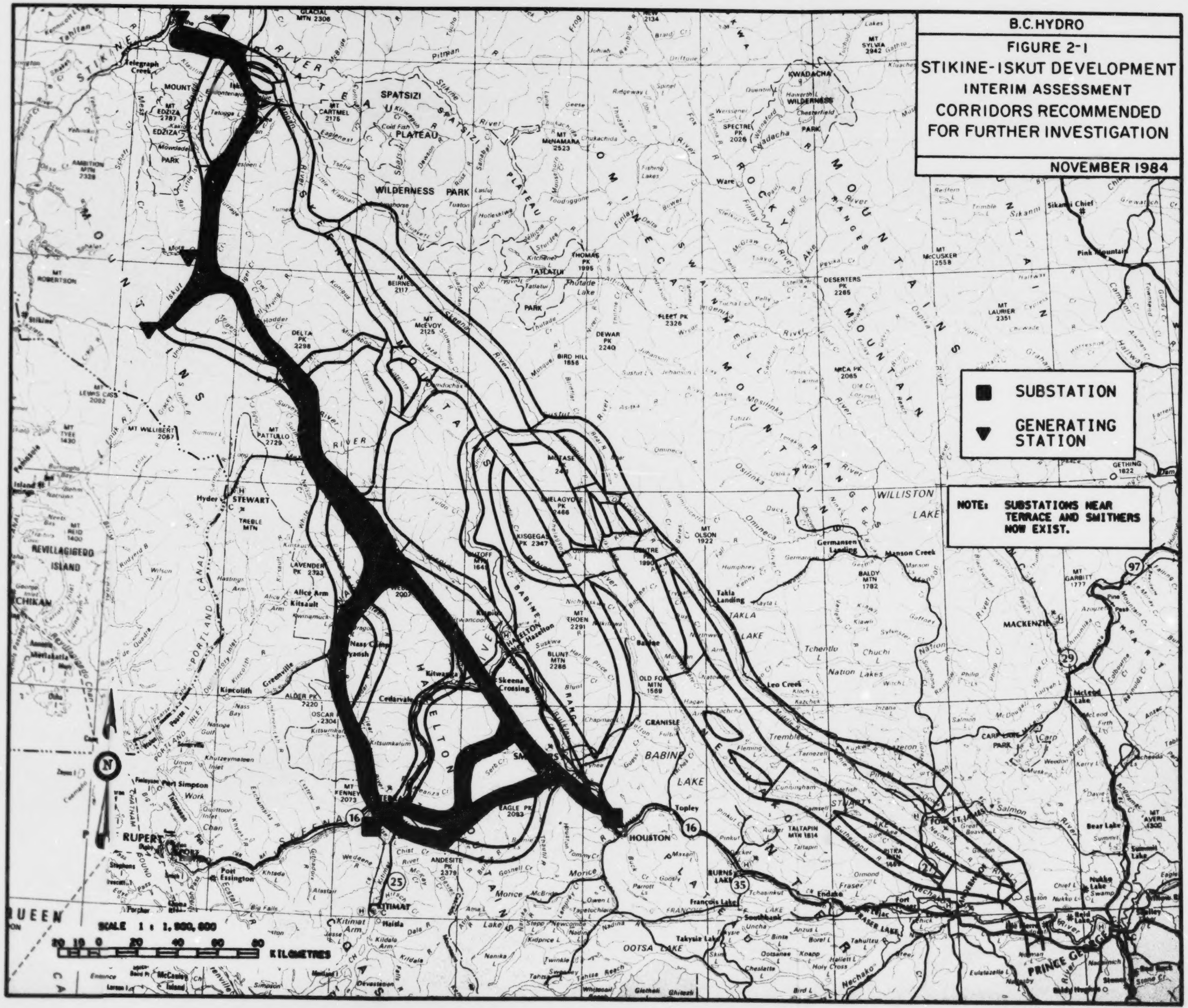
2. Community Relations field staff would be assigned in sufficent time and local public contact would be initiated three to six months in advance of the resumption of technical and environmental field studies.

3. Terms of reference for socio-economic and relevant environmental impact studies would be developed in conjunction with local residents prior to assignment to consultants or Hydro staff.

4. More attention would be given to development of forums for discussion of corporate planning policy issues in conjunction with project-specific issues.

5. More effort would be directed to creating a better awareness within Hydro of the size and remoteness of the study area and the time frame needed to develop effective dialogue and local understanding of project size and complexity.

6. Public information and consultation programs would not cease upon application for an EPC, but would continue through project approval and construction.


SUBSTATION
GENERATING STATION
SCALE 1 : 1,900,000
20 10 0 20 40 60 80 KILOMETRES
N
SPATSIZI PLATEAU WILDERNESS PARK
MOUNT EDZIZA PARK
STIKINE
Telegraph Creek
Iskut
Stikine
MT EDZIZA 2787
AMBITION MTN 2328
MT ROBERTSON
MT CARTMEL 2176
MT BEIRNES 2117
MT McEVOY 2125
DELTA PK 2298
MT LEWIS CASS 2082
MT WILLIBERT 2087
MT PATTULLO 2729
MT TYEE 1430
Hyder
STEWART
TREBLE MTN
LAVENDER PK 2323
Alice Arm
Kitsault
REVILLAGIGEDO ISLAND
KETCHIKAN
PORTLAND CANAL
PORTLAND INLET
Greenville
Kincolith
Nass Camp
Aiyansh
ALDER PK 2220
OSCAR 2304
Cedarvale
Kitwanga
HAZELTON
Hazelton
Skeena Crossing
SMITHERS
TERRACE
MT KENNEY 2073
EAGLE PK 2083
ANDESITE PK 2379
HOUSTON
Topley
BURNS LAKE
Francois Lake
KITIMAT
Kitimat Arm
Port Simpson
RUPERT
Port Essington
Chatham Sound
BABINE LAKE
GRANISLE
TAKLA LAKE
Takla Landing
Tchentlo L
Chuchi Lake
Nation Lakes
Leo Creek
Trembleur L
STUART L
FORT ST JAMES
Fraser L
Endako
Vanderhoof
PRINCE GEORGE
OOTSA LAKE
MT McNAMARA 2523
THOMAS PK 1995
Thutade Lake
DEWAR PK 2240
BIRD HILL 1858
FLEET PK 2326
MUTASE 2487
SHELAGYOTE PK 2446
KISGEGAS PK 2347
MT THOEN 2291
BLUNT MTN 2286
OLD FORT MTN 1569
MT OLSON 1922
OMINECA MOUNTAINS
SWANNELL RANGES
ROCKY MOUNTAINS
MUSKWA RANGES
KWADACHA WILDERNESS PARK
SPECTRE PK 2026
MT SYLVIA 2942
DESERTERS PK 2265
MICA PK 2085
MT McCUSKER 2558
MT LAURIER 2351
Pink Mountain
Sikanni Chief
GETHING 1822
WILLISTON LAKE
Germansen Landing
Manson Creek
BALDY MTN 1782
MT GARBITT 1777
MACKENZIE
McLeod Lake
Bear Lake
MT AVERIL 1300
Salmon
CARP LAKE PARK
TALTAPIN MTN 1814
PITKA MTN
HAZELTON MOUNTAINS
SKEENA MOUNTAINS
NECHAKO PLATEAU
QUEEN CHARLOTTE

B.C.HYDRO

FIGURE 2-1

STIKINE-ISKUT DEVELOPMENT

INTERIM ASSESSMENT

CORRIDORS RECOMMENDED FOR FURTHER INVESTIGATION

NOVEMBER 1984

NOTE: SUBSTATIONS NEAR TERRACE AND SMITHERS NOW EXIST.

STIKINE CANYON PROJECT
GEOTECHNICAL EXPLORATION COMPLETED TO 31 DECEMBER 1983
SUMMARY OF SELECTED QUANTITIES

ACTIVITY	1978	1979	1980	1981	1982	1983	TOTAL
SITE EXPLORATION							
(a) GEOLOGICAL MAPPING - DETAILED	Initial Map	Joint Survey	Selective Mapping	Selective Mapping	Selective Mapping	Selective Mapping	-
(b) GEOPHYSICAL SURVEYS (LINE-METERAGE)							
Seismic Refraction - Box Canyon Area	1450	-	-	-	-	-	1450
Seismic Refraction - Main Dam Left Abutment	-	2300	-	-	-	-	2300
Seismic Refraction/Reflection - Main Dam Left Abutment	-	-	-	630	-	-	630
Seismic (Downhole)	-	200	-	-	261	-	461
Gravity (Box Canyon)	-	5275	-	2200	-	-	7475
Magnetic (Box Canyon)	-	5275	-	-	-	-	5275
Downhole Geophysical Logging (M of Hole)	1134	791	592	253	1490	-	4260
Transient Electro-Magnetic	-	-	-	-	2400	-	2400
(c) DIAMOND DRILLING							
No. of Holes - Surface	7	14	4	13	20	-	58
- Underground	-	-	-	10	25	-	35
- Underground, Rock Mechanics	-	-	-	36	-	-	36
- Total	7	14	4	59	45	-	129
Meterage Drilled							
Rock - Surface	1315	1553	678	1335	2818	-	7699
Rock - Underground	-	-	-	1553	3525	-	5078
Rock - Underground, Rock Mechanics	-	-	-	269	-	-	269
Rock - Total	1315	1553	678	3157	6343	-	13046
Soils - With Sampling	109	465	-	420	195	-	1189
Soils - Without Sampling	75	63	37	432	259	-	866
Soils - Total	184	528	37	852	454	-	2055
Total Meterage	1499	2081	715	4009	6794	- -	15101
(d) EXPLORATORY ADITS							
1. Lower Right Abutment (m)	-	-	50	760	-	-	810
1A. Lower Right Abutment (m)	-	-	-	-	393	-	393
2. Upper Right Abutment (m)	-	-	-	258	-	-	258
3. Upper Left Abutment (m)	-	-	-	115	-	-	115
4. Lower Left Abutment (m)	-	-	-	-	196	-	196
Total	-	-	50	1131	589	-	1772
(e) SAMPLING (No. of Samples Taken)							
Rock Drill Cores	46	36	116	-	260	-	458
Soil Samples	11	57	-	79	37	-	184
LD Cores	-	-	-	-	20	-	20
Bulk Samples	-	-	-	-	-	4	4
(f) LAB TESTING (No. of Tests)							
Rock Drill Cores	46	36	116	-	175	20	393
Soil Samples	33	132	-	191	149	-	505
LD Cores	-	-	-	-	15	-	15
Bulk Samples	-	-	-	-	-	4	4
CONSTRUCTION MATERIALS EXPLORATION							
(a) GEOLOGICAL MAPPING - REGIONAL	Initial Map	Selective Mapping	-	Selective Mapping	Selective Mapping	Selective Mapping	-
(b) FIELD EXPLORATION							
Hand-Dug Test Pits (No.)	15	12	28	171	6	-	232
Machine-Dug Test Pits (No.)	-	-	-	45	42	-	87
Auger Holes (No.)	-	18	-	55	9	-	82
Auger Holes (Total Meterage)	-	144	-	407	78	-	629
Becker Holes (No.)	-	-	-	-	41	-	41
Becker Holes (Total Meterage)	-	-	-	-	487	-	487

TANZILLA PROJECT
GEOTECHNICAL EXPLORATION COMPLETED TO 31 DECEMBER 1983
SUMMARY OF SELECTED QUANTITIES

ACTIVITY	1978	1979	1980	1981	1982
SITE EXPLORATION					
(a) GEOLOGICAL MAPPING - DETAILED	Initial Map	-	-	Selective Mapping	Selective Mapping
(b) GEOPHYSICAL SURVEYS (line meters)					
- Seismic Refraction					
i) power tunnel	-	-	2400	-	-
ii) reservoir area	-	-	-	-	3645
- Aeromagnetic	-	-	35700	-	-
- Gravity	-	-	-	8400	-
- Downhole Geophysical Logging - Reservoir Area	-	-	-	-	536
(c) i) DIAMOND DRILLING - SITE					
No. of Holes - Surface	3	-	-	7	19
- Underground	-	-	-	-	-
- Total	3	-	-	7	19
Meterage Drilled					
Rock - Surface	370	-	-	1171	3674
Rock - Underground	-	-	-	-	-
Rock - Total	370	-	-	1171	3674
Soils	16	-	-	201	337
Total Meterage	386	-	-	1372	4011
(c) ii) DIAMOND DRILLING - RESERVOIR AREA					
No. of Holes - Surface	-	-	-	-	5
Meterage Drilled					
Rock	-	-	-	-	519
Soil	-	-	-	-	143
Total	-	-	-	-	662
(d) EXPLORATORY ADITS					
1. Powerhouse area (m)	-	-	-	-	187
(e) SAMPLING (No. of Samples Taken)					
Rock Drill Cores	-	-	7	18	52
Soil Samples	-	19	-	20	-
(f) LAB TESTING (No. of Tests)					
Rock Drill Cores	-	-	7	18	50
Soil Samples	-	19	-	20	-
CONSTRUCTION MATERIALS EXPLORATION					
(a) GEOLOGICAL MAPPING - REGIONAL	Initial Map	Selective Mapping	-	Selective Mapping	Selective Mapping
(b) FIELD EXPLORATION					
Hand-Dug Test Pits (No.)	3	3	-	48	-
Machine-Dug Test Pits (No.)	-	-	-	3	28
Auger Holes (No.)	-	3	-	-	25
Auger Holes (Total Meterage)	-	15	-	-	122

STIKI
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SUM

DATE

DWN

REPORT

TANZILLA PROJECT
GEOTECHNICAL EXPLORATION COMPLETED TO 31 DECEMBER 1983
SUMMARY OF SELECTED QUANTITIES

	1978	1979	1980	1981	1982	1983	TOTAL
ING - DETAILED	Initial Map	-	-	Selective Mapping	Selective Mapping	Selective Mapping	-
VEYS (line meters)							
ction							
el	-	-	2400	-	-	-	2400
area	-	-	-	-	3645	-	3645
	-	-	35700	-	-	-	35700
ysical Logging -	-	-	-	8400	-	-	8400
Area	-	-	-	-	536	-	536
ING - SITE							
Surface	3	-	-	7	19	-	29
- Underground	-	-	-	-	-	-	-
- Total	3	-	-	7	19	-	29
lled							
ce	370	-	-	1171	3674	-	5215
rground	-	-	-	-	-	-	-
l	370	-	-	1171	3674	-	5215
	16	-	-	201	337	-	554
	386	-	-	1372	4011	-	5769
LING - RESERVOIR AREA							
Surface	-	-	-	-	5	-	5
ed							
	-	-	-	-	519	-	519
	-	-	-	-	143	-	143
	-	-	-	-	662	-	662
S							
area (m)	-	-	-	-	187	-	187
Samples Taken)							
	-	-	7	18	52	-	77
	-	19	-	20	-	-	39
of Tests)							
	-	-	7	18	50	-	75
	-	19	-	20	-	-	39
S EXPLORATION							
G - REGIONAL	Initial Map	Selective Mapping	-	Selective Mapping	Selective Mapping	Selective Mapping	-
N							
s (No.)	3	3	-	48	-	10	64
Pits (No.)	-	-	-	3	28	-	31
)	-	3	-	-	25	-	28
l Meterage)	-	15	-	-	122	-	137

BRITISH COLUMBIA HYDRO AND POWER AUTHORITY

STIKINE - ISKUT DEVELOPMENT
STIKINE CANYON & TANZILLA PROJECTS

SUMMARY OF EXPLORATION

DATE DEC 1984

TABLE 2-1A

DWN SMD

DWG No. 915-C14-C864

REPORT No. H1720

ISKUT CANYON PROJECT

GEOTECHNICAL EXPLORATION COMPLETED TO 31 DECEMBER 1983

SUMMARY OF SELECTED QUANTITIES

SITE EXPLORATION	PRE-1979	1979	1980	1981	1982	1983	TOTAL
(a) GEOLOGICAL MAPPING - DETAILED	Initial Mapping (1964/65 & 1971)	Selective (Site)	Selective (Site) Dolmage Campbell)	Selective (Site) Regional (Geotex)	Selective (Site) Regional (Geotex)	Selective (Site) Regional (Hydro + Geotex)	-
(b) GEOPHYSICAL SURVEYS (LINE-METERAGE)							
Seismic Refraction - Lava Flats	-	-	-	6500 <6>	-	-	6500 <6>
Seismic Refraction/Reflection - Lava Flats	-	-	4400 <4>^{2}	-	-	-	4400 <4>
Resistivity/Induced Polarization - Lava Flats	-	-	4300 <3>	-	-	-	4300 <3>
Gravity - Lava Flats	-	-	18700 <14>	17200 <8>	-	-	35900 <22>
Seismic (Downhole) - Iskut Canyon	-	300 (3)^1	-	-	-	-	300 (3)
Downhole Geop. Logging - Iskut Canyon	-	450 (3)	-	-	-	-	450 (3)
Downhole Geop. Logging - Saddle Dam	-	-	-	476 (5)	4465 (45)	-	4941 (50)
(c) DRILLING							
No. of Holes - Diamond (NQ-EX) - Iskut Canyon	2 [64/65]	3	-	-	5	-	10
- Diamond (PQ-BQ) - Lava Flats	1 [64/65]	8	3	14	16	-	42
- Non-Core (25cm-8cm Ø) - Lava Flats	-	-	-	-	31	-	31
- TOTAL	3	11	3	14	52	-	83
Meterage Drilled:							
Diamond Core - Iskut Canyon	273	566	-	-	1091	-	1930
Diamond Core - Lava Flats	64	826	222	2145	937	-	4194
Non-Core - Lava Flats	-	-	-	-	3617	-	3617
TOTAL	337	1392	222	2145	5645	-	9741
(d) GROUNDWATER INVESTIGATIONS							
No. of Holes Completed with one or more Piezometers - Lava Flats	-	2	2	9	45	-	58
Permeability Tests (No.):							
Infiltration Tests - Lava Flats	-	-	1^3	-	1	5 (2)	7 (3)
Pump Tests - Lava Flats	-	-	-	3	1	2 (1)	5 (2)
Groundwater Tracer Tests - Lava Flats	-	-	-	-	2	-	2
Packer Tests - Iskut Canyon	-	57 (3)	-	-	104 (5)	-	161 (8)
(e) SAMPLING							
Rock Drill Cores (No.)	-	32	15	17	34	4	102
Soils (No.)	-	-	-	-	26	2	28
(f) LABORATORY AND INSITU TESTING							
Borehole Jack Tests - Rock	-	-	-	-	64 (3)	-	64 (3)
Unconfined Compression Tests - Rock	-	11	-	10	34	-	55
Triaxial Tests - Rock	-	10	2	5	-	-	17
Direct Shear Tests - Rock	-	1	-	2	-	-	3
Static Modulus Tests - Rock	-	3	-	4	27	-	34
Dynamic Modulus Tests - Rock	-	6	-	10	33	-	49
Basic Friction Tests - Rock	-	-	-	-	44	-	44
Classification Tests - Soils	-	-	-	-	26	2	28
X-Ray Diffraction - Lava Material	-	-	-	-	5	-	5
Petrographic Examination (No.) - Rock	-	10	13	-	-	4	27
(g) RADIOMETRIC DATING							
Damsite - ^{14}C Dates (incl. Geotex)	-	-	-	1	4	9	14
- K-Ar Dates	-	-	-	-	-	3	3
Regional - ^{14}C Dates	-	-	-	-	-	2	2
- K-Ar Dates	-	-	-	-	-	2	2

ISKUT CANYON & MORE CREEK PROJECTS

CONSTRUCTION MATERIALS INVESTIGATIONS COMPLETED TO 31 DECEMBER 1983

SUMMARY OF SELECTED QUANTITIES

MATERIALS EXPLORATION	PRE-1979	1979	1980	1981	1982	1983	TOTAL
Hand-Dug Test Pits (No.)	-	7	-	-	10	-	17
Machine-Dug Test Pits (No.)	-	-	-	-	52	-	52
Auger Holes (No.)	-	3	-	-	23	-	23
Auger Holes (Total Meterage)	-	10	-	-	235	-	245

MORE CREEK PROJECT

GEOTECHNICAL EXPLORATION COMPLETED TO 31 DECEMBER 1983

SUMMARY OF SELECTED QUANTITIES

SITE EXPLORATION	PRE-1979	1979	1980	1981	1982	1983	TOTAL
(a) GEOLOGICAL MAPPING - DETAILED	Initial Mapping (1971)	Selective (Site)	Selective (Size) (Dolmage Campbell & Geotex)		-	Reconnaissance Mapping	-
(b) GEOPHYSICAL SURVEYS (LINE METERAGE)							
Seismic (Downhole)	-	210 (3)	-	-	-	-	210 (3)
Downhole Geop. Logging	-	270 (3)	-	-	-	-	270 (3)
(c) DRILLING							
No. of Holes - Diamond (NQ)	-	3	-	3	-	-	6
Meterage Drilled - Diamond Core	-	540	-	560	-	-	1100
(d) GROUNDWATER INVESTIGATIONS							
Permeability Tests							
Packer Tests	-	28 (3)	-	-	-	-	28 (3)
(e) SAMPLING							
Rock Drill Cores (No.)	-	21	11	19	29	-	80
(f) LABORATORY AND INSITU TESTING							
Borehole Jack Tests - Rock	-	-	-	-	44 (2)	-	44 (2)
Unconfined Compression Tests - Rock	-	3	4	9	29	-	45
Triaxial Tests - Rock	-	6	-	8	-	-	14
Direct Shear Tests - Rock	-	-	-	2	-	-	2
Static Modulus Tests - Rock	-	3	4	6	23	-	36
Dynamic Modulus Tests - Rock	-	6	-	9	28	-	43
Petrographic Examination - Rock	-	12	7	-	-	-	19
FORREST KERR DIVERSION SITE EXPLORATION							
(a) GEOLOGICAL MAPPING - DETAILED	-	Selective (Site)	-	-	-	-	-
(b) PETROGRAPHIC EXAMINATION - ROCK	-	4	-	-	-	-	4

NOTES:

1. "( )" indicates the number of boreholes the testing or logging was preformed in.
2. "< >" indicates the number of cut-lines surveyed by Geophysical methods.
3. Eight cross-hole water tests (non-standard) were attempted and only one test was partially successful.

BRITISH COLUMBIA HYDRO AND POWER AUTHORITY

STIKINE - ISKUT DEVELOPMENT
ISKUT CANYON & MORE CREEK PROJECT

SUMMARY OF EXPLORATION

DATE DEC 1984
TABLE 2-1B
DWN JB
DWG No. 913-C14-B458

REPORT No. H1720

SECTION 3.0 - DESCRIPTION OF PROPOSED DEVELOPMENT

3.1 FEATURED DEVELOPMENT

This section describes the four dams and powerplants, transmission and other related facilities comprising the proposed Stikine-Iskut Development. The environmental impact assessment presented in Section 5 of this report is based on this description.

As previously noted this report was prepared prior to completion of the program of studies leading to an application for an energy project certificate. Hence the project descriptions are interim and may change following further study. Nevertheless, the development described is the most likely and sufficient detail is provided to enable an environmental impact assessment.

Alternatives to the development described below are reviewed in Section 7 along with a discussion of the differences in environmental impacts.

3.2 GENERATION PROJECTS

3.2.1 PROPOSED DEVELOPMENT

The two Stikine projects would be located within the Grand Canyon of the Stikine, as shown on the river profiles on Fig. 3-1. The total gross head developed by the two Stikine River projects would be 514 m. This would be almost equally divided between the two.

The Stikine Canyon project would provide a high degree of flow regulation, with spillway releases averaging only 4 percent of total flows, thus yielding near maximum possible energy production from this project and from the downstream Tanzilla Project. This substantial flow regulation is afforded by the Stikine Canyon reservoir which, with an operational drawdown of 45 m, would provide live storage of 4300 x 10^6 m^3. The reservoir would have a total length of 103 km, an average width of 1½ km and a maximum surface area of 12600 ha.

The Tanzilla Project involves a dam located 23 km downstream from Stikine Canyon connected to the powerhouse by a 5 km power tunnel. The Tanzilla reservoir would be operated on a run-of-river basis with no seasonal drawdown. The reservoir level would be matched to the Stikine Canyon tailwater level, with a reservoir area of 850 ha and an average width of 0.4 km.

The proposed Iskut Canyon and More Creek projects shown on Fig. 3-2 would develop an average gross head of 192 m at the Iskut Canyon project for a 810 MW powerplant and 141 m at the More Creek Project for a 170 MW powerplant. Flow regulation and power production from the combined projects would be enhanced by diversion of Forrest Kerr Creek into the More Creek reservoir. A high degree of flow utilization for power generation would be achieved in the Iskut Canyon reservoir through a 35 m reservoir drawdown, providing 900 million m^3 of live storage. Regulation of More Creek flows would further improve Iskut Canyon flow utilization. The More Creek reservoir would provide virtually complete regulation of More Creek flows including those from Forrest Kerr Creek, with a drawdown of 42 m and consequent live storage of 1500 million m^3. Diversion of Forrest Kerr Creek into the More Creek reservoir would increase the average flow at the More Creek Project by about 42 percent.

3.2.2 STIKINE CANYON PROJECT

a) General Description

The Stikine Canyon site is located in the Grand Canyon of the Stikine River approximately 25 km downstream of the Highway 37 river crossing. As shown on Fig. 3-3, the main damsite is located in a deep, narrow section of the canyon immediately downstream of an abrupt river bend and approximately 800 m upstream of the confluence of a small unnamed tributary flowing through a wide, but short box canyon joining the Stikine River from the east. The secondary, although still major, damsite is located about 650 m up the box canyon from the Stikine River.

The site is sparsely forested with new growth, and is liberally covered with dead-falls and snags as a result of the whole area having been burned over, possibly in the late 1950's.

In addition to the main and box canyon dams, the featured project arrangement includes a connecting concrete gravity dam, auxiliary spillway on the right bank of the box canyon, power facilities and a diversion tunnel (Figs. 3-3 to 3-6).

b) Diversion

A single tunnel in the right abutment would be provided for diversion (see Fig. 3-3 to 3-5). The tunnel would be shotcrete lined, horseshoe shaped, 13.7 m in diameter, and 550 m long. The intake would be submerged, but the tunnel would have free-surface flow regime at design flow.

An upstream cofferdam would be built to enable flows with return periods of up to 1 in 10 years (2280 m^3/s) to be passed with 1.5 m cofferdam freeboard. A downstream cofferdam would be also required for construction of the dam.

Diversion would commence in the fall of the 2nd year of construction and all flows would be passed until construction of the dam was complete. Closure of the diversion tunnel would commence reservoir filling about Nov. 1 of the 7th year of construction.

c) Main Dam

The proposed main dam would be a concrete arch with a maximum height of 270 m and a developed crest length of about 375 m.

Thrust blocks would be required to complete the arch support at both upper flanks of the dam.

A grout curtain with a maximum depth of 90 m would be provided in the arch dam foundations and abutments in conjunction with a downstream curtain of drain holes to ensure control of seepage through the rock. To facilitate grouting and drainage a system of galleries in the dam and drainage tunnels into the abutments would be required.

Freeboard of 3.0 m above the maximum normal reservoir level would be provided, with this freeboard being reduced to zero during passage of the probable maximum flood (PMF).

d) Box Canyon Dam

The box canyon dam would be an embankment dam with central impervious till core, inclined slightly upstream, and rockfill shells (Fig. 3-3 and 3-4). Both upstream and downstream slopes would be 1.75H:1V except the upstream slope below El. 700 would be flattened to 2H:1V. All till would be removed from the foundation of the box canyon rockfill dam. The filter/transition would be non-cohesive, self-healing sand and gravel.

Freeboard of 9.0 m above the maximum normal reservoir level would be provided, with this freeboard being reduced to 6.0 m during passage of the PMF.

A 430 m long gravity dam, incorporating the power intakes and concrete transition, is required to complete closure between the box canyon dam and the main dam.

e) Hydraulic Structures

The hydraulic structures consist of low level outlets, service outlets and an auxiliary spillway (Table 3-1). The total discharge capacity required to pass the PMF would be provided by the combined operation of the service outlets and the auxiliary spillway.

i) Low Level Outlets

Low level outlets are required to control reservoir levels and maintain minimum daily riparian flow releases downstream of the dam during the initial period of reservoir filling.

In conjunction with the service outlets, the low level outlets could be used for reservoir evacuation if ever required.

ii) Service Outlets

Service outlets would be provided to:

1. allow downstream riparian releases of water during initial reservoir filling, and subsequently with powerhouse shutdown;
2. limit reservoir filling rates and limit use of the auxiliary spillway facilities to extreme floods;
3. allow reservoir drawdown for flood routing purposes prior to major flood;

4. allow partial reservoir evacuation, in conjunction with low level outlets, if ever required.

Service outlet facilities would consist of four outlets controlled by jet flow gates and provide discharge capacity, with reservoir routing, to pass about a 1000-year return period flood through the reservoir without use of the auxiliary spillway, assuming an initial reservoir drawdown of 25 m or more.

iii) Auxiliary Spillway

The capacity and crest elevation of the auxiliary spillway have been selected so as to limit the maximum reservoir level to El. 797 during the PMF assuming:

1. 25 m initial reservoir drawdown to El. 769;
2. zero discharge from the powerhouse; and
3. full capacity discharge from the service outlets.

Power studies indicate that drawdown due to powerplant operation alone during the winter months prior to the spring freshet would result in a reservoir level of less than 769 m about 94 percent of the time.

The auxiliary spillway would consist of a multi-gate controlled concrete chute terminating in a flip bucket. The flip bucket elevation and throw angle have been selected so as to cause the spillway discharge jet to land within the natural river channel.

f) Power Facilities

The power intakes are located upstream of the concrete gravity dam and would comprise three inlets. The individual penstocks, each about 420 m long, would be concrete lined. The powerhouse would contain three generating units, each having a Francis turbine and generator capable of a maximum continuous output of 320 MW. Two 500 kV circuits would transmit power from the terminal equipment building to the Stikine Collector Switching Station located on the south side of the reservoir.

Power flows would be conveyed back to the river via three concrete lined tailrace tunnels.

Improvement of the river channel for 420 m downstream of the tailrace tunnel portals would reduce the backwater between the Tanzilla reservoir and the Stikine Canyon tailrace.

g) Reservoir

The proposed maximum normal reservoir level is El. 794, and with the selected drawdown depth of 45 m, the minimum reservoir level would be El. 749. Based on power studies with the installed capacity described above, the average reservoir level would be El. 779 m. With a 3.0 m flood surcharge permitted during passage of the PMF, the maximum reservoir level would be El. 797.

At maximum normal reservoir level the total reservoir storage would be 7200 million m^3 and the total area would be 12600 ha, and with 45 m drawdown the live storage would be 4300 million m^3. The total reservoir length is about 103 km including all reservoir arms, with the reservoir width averaging about 1-1/4 km.

The inundated areas would consist of unimproved valley slopes. All merchantable timber would be removed and all non-merchantable timber above 7.5 cm in diameter would be felled or knocked down, piled and burned, in all areas above the minimum reservoir level and in areas where the tree tops are 5 meters or less below the minimum reservoir level.

h) Construction Facilities

A preliminary layout of the construction facilities and work areas required for construction purposes is shown on Fig. 3-7.

Upon completion of construction, these areas will be reclaimed and restored.

Most of the construction facilities would be located on the north bank as most of the project structures, including the diversion tunnel, powerhouse, spillway and box canyon dam, would be on this side of the river. In addition, the box canyon provides a natural access to the Stikine riverbed. Along this section of the river the canyon walls are very steep and access to the riverbed from the south bank would be extremely difficult. A bridge crossing the river in this area has been studied and set aside at this stage, based on cost and time required for construction.

The following main facilities and construction areas have been identified on the drawings:

- Townsite
- B.C. Hydro Construction Facilities
- Borrow and Spoil Areas
- Contractors Work Areas
- Concrete Placement Facilities

Investigations for construction materials have identified suitable till and quarry areas in the vicinity of the site. The concrete aggregate and granular material (filter and drains) for the box canyon dam would come from Area 1 on the Stikine River banks adjacent to the Highway 37 crossing. It is expected that the aggregate would be processed in a plant located in the borrow area and hauled to the site, a distance of about 32 km. This area would be inundated by the reservoir following project completion.

There is no suitable spoil area below the future reservoir level for the 11 million m^3 of the overburden to be excavated for the box canyon dam. The area allocated is the closest available, minimizing the significant haul costs. The spoil would be placed and graded to stable slopes and reseeded.

i) Construction Schedule

Construction of the Stikine Canyon project would take 7-3/4 years. Assuming that the first contract is awarded on 1 January of year 1, the in-service dates would be

Units 1 & 2	1 Oct year 8
Unit 3	1 Jan year 9

3.2.3 TANZILLA PROJECT

a) General Description

The Tanzilla damsite is located in the Grand Canyon of the Stikine 23 km downstream from the Stikine Canyon Project and 4.7 km upstream from the Tanzilla River confluence with the Stikine River. The Tanzilla powerhouse site is located about 2.2 km downstream from this confluence.

b) Diversion

A single tunnel in the left abutment would be provided for diversion (see Fig. 3-8 to 3-10). The tunnel would be shotcrete lined, horseshoe shaped, 13.9 m in diameter, and 420 m long. The intake would be submerged, but the tunnel would have free-surface flow regime at design flow.

An upstream cofferdam would be constructed to enable passing the design flow (2330 m^3/s) with a return period of 1 in 10 years while retaining 1.5 m cofferdam freeboard. A smaller downstream cofferdam would be required for construction of the dam.

Diversion would commence in the fall of the 2nd year of construction and all flows would be passed until construction of the dam was complete. Closure of the diversion tunnel would commence reservoir filling about Nov. 1 of the 6th year of construction.

c) Dam

The proposed dam would be a concrete arch with a maximum height of 193 m and a developed crest length of about 528 m. With the exception of the thrust blocks, which are not needed at Tanzilla, the dam and appurtenances would be similar to those at Stikine Canyon.

d) Hydraulic Structures

Except for some minor differences discussed below, the hydraulic structures for Tanzilla would be similar to those at the Stikine Canyon Project, and provide identical service. The details are given in Table 3-2.

The release of flood waters from reservoirs by means of spillways has been identified in many cases as causing an adverse water quality condition referred to as dissolved gas supersaturation, wherein concentrations of dissolved gases are well above normal equilibrium levels in river water. This condition may lead to permanent injury or death of fish and other aquatic species, caused by the dissolved gases coming out of solution and forming gas bubbles within the blood stream.

Experience to date has indicated that gas supersaturation levels in the outfall areas of free fall type spillways, as are proposed for the Tanzilla and Stikine Canyon projects would generally not exceed 120%. Due to the steep, rough nature of the river channel in the 7 km reach between the Tanzilla dam and the powerhouse, which would tend to return the supersaturation level toward to equilibrium conditions, and combined with the mixing of powerhouse and spillway flows, the level of dissolved gas supersaturation downstream of the powerhouse would be expected to drop below 110%. Further downstream, the presence of turbulent reaches and the addition of tributary flows may further reduce the level of gas supersaturation.

e) Power Facilities

The power tunnel intake comprises an integral bell-mouth inlet and fixed-wheel gate.

The power tunnel, approximately 4.5 km long from inlet to surge shaft, is assumed to be excavated to 12.0 m in diameter by tunnel boring machine.

The smooth bored tunnel would be unlined, except for occasional local concrete lining, rock bolt and shotcrete support where dictated by any geological defects encountered. A surge shaft would be excavated immediately upstream of the penstock trifurcation and valve chamber.

The powerhouse would be virtually identical to that for the Stikine Canyon Project. Two 500 kV transmission circuits are assumed to transmit the power from the Tanzilla Project to the Stikine Collector Switching Station, located in the vicinity of the Stikine Canyon Project. Flows would be conveyed back to the river via individual tailrace tunnels. The powerhouse setting is based on channel improvements being made over a 250 m reach downstream of the powerhouse.

f) Reservoir

The proposed maximum normal reservoir level is El. 531. With a 3.0 m flood surcharge permitted during passage of the PMF the maximum reservoir level would be El. 534.

At maximum normal reservoir level the total reservoir area would be 850 ha, and the total dead storage would be 560 million m^3. The reservoir length would be about 23 km, extending back to the Stikine Canyon Project with the reservoir width averaging about 400 m.

The forest cover within the Tanzilla reservoir is limited in extent due to frequency of precipitous canyon walls. All merchantable timber would be removed and all non-merchantable timber above 7.5 cm in diameter would be felled or knocked down, piled and burned, in all areas above the minimum reservoir level and in areas where the tree tops are 5 meters or less below the minimum water level. The estimated net area to be cleared on this basis is approximately 120 ha, all by hand clearing methods.

g) Construction Facilities

A preliminary layout of the construction facilities and work areas required for construction purposes is shown on Fig. 3-11. The areas shown may not be used in their entirety.

It is expected that, upon completion of construction, these areas will be reclaimed and restored.

Most of the construction facilities would be located south of the Stikine River as substantially all of the project structures would be located on this side. Limited suitable level areas are available at the damsite and powerhouse because of the steepness of the canyon walls at these locations. The construction facilities would be located in three separate areas because of the 5 km distance between the damsite and powerhouse.

h) Construction Schedule

Construction of the Tanzilla project would take 6¼ years. Assuming that the first contract is awarded on 1 January of year 1, the in-service dates would be

Units 1 & 2	1 May year 7
Unit 3	1 Aug year 7

3.2.4 ISKUT CANYON PROJECT

a) GENERAL DESCRIPTION

The Iskut Canyon Project would be located in Iskut Canyon just downstream of the Forrest Kerr Creek confluence. The general arrangement is shown on Fig. 3-12. For a distance of 4 - 5 km downstream of the confluence downcutting by the Iskut river has produced a narrow canyon in which the main dam would be located, approximately 2 km downstream from the confluence. Infilling by lava of ancient channels of the Iskut River located on left side of the valley has created the lava flats, where a saddle dam would be required. In addition to the main and saddle dams, the featured project arrangement consists of an auxiliary spillway on the left abutment, a low level outlet, an intermediate level outlet, diversion tunnels and power facilities within the left bank and a fuse plug spillway on the lava flats. Figs. 3-13 and 3-14 show the main canyon site. Fig. 3-15 shows the saddle dam and Fig. 3-16 shows the power facilities.

b) Diversion

Diversion during construction would be accomplished by two tunnels in the left bank. The tunnels would be 8.4 m concrete lined horseshoe shaped tunnels 770 m and 810 m long. The intakes for the diversion tunnels would be submerged and the tunnels would not flow full at design flow.

The tunnel exit portal inverts would be located about 10 m above the tailwater level for the diversion design flow (see Figs. 3-13 and 3-14). The exit structures of the tunnels would consist of simple flip buckets to throw the flow into the middle of the river channel.

A first stage rockfill cofferdam would initiate diversion of the river through the tunnels by 1 November of the third year of construction. Once diversion was established a 2nd stage rockfill cofferdam would be built to El. 241.5. The combination of the 30 m high upstream cofferdam with the two diversion tunnels would enable flows with a return period of 1 in 30 years to be passed without overtopping the cofferdam. A small downstream cofferdam would be built just upstream of the diversion tunnel outlets.

Closure of the south tunnel for construction of the low level outlets would commence on 15 October of the 6th year of construction. The low level outlets would be completed and the south tunnel reopened by 15 April of the 7th year of construction. Reservoir filling would commence with the closing of the north tunnel on 15 April of the 7th year of construction.

c) Main Dam

The main dam would consist of a 180 m high impervious core embankment dam with an auxiliary spillway and small gravity dam on the left bank. The embankment would wrap around a concrete transition structure adjacent to the auxiliary spillway. The crest elevations of the embankment and concrete gravity dam would be 356.0 and 350.0 respectively. The crest width of the embankment would be 9.0 m. The total crest length would be 640 m.

The impervious till core would be sloped slightly upstream and have a ratio of core width to net reservoir head of 0.5.

The shell of the embankment dam would consist of sand and gravel. The slopes of the shells would be 2.25H:1V and 2H:1V upstream and downstream respectively. The embankment dam would have 6.0 m freeboard above the PMF reservoir level at El. 350. The normal maximum reservoir level would be 347 m. The upstream shell of the dam would incorporate the upstream cofferdam.

d) Saddle Dam

The saddle dam shown on Fig. 3-15 would be a rockfill embankment with an upstream concrete face. The maximum height would be about 56 m and the crest length would be 1.3 km. The dam would be constructed of rockfill obtained from a quarry located at the right end of the dam. The quarry would later be used for the fuse plug spillway.

To reduce seepage under the dam a grout cutoff to basement rock would be constructed across the middle and north channels. Drilling in the Lava Flats would be difficult and would probably require the use of large drill rigs; consequently the drilling would be done from the surface. Provision would be made for access along the upstream face of the dam to facilitate additional grouting or facing repairs, if required, during annual low reservoir water levels.

e) Hydraulic Structures

The hydraulic structures consist of a low level outlet, an intermediate level outlet, an auxiliary spillway and a fuse plug spillway. The total discharge capacity required to pass the probable maximum flood would be provided by the combined operation of all hydraulic structures except the low level outlet.

i. Low Level Outlet

The low level outlet shown on Fig. 3-13 would be constructed in the south diversion tunnel during the last winter of diversion and would be an expansion chamber type energy dissipator. This would involve two concrete plugs with three slide gates per plug to retain a pressurized water-filled chamber between them. A bulkhead gate would be installed in a shaft upstream of the low level outlet to enable maintenance of the installation over the long-term.

The low level outlet would be used for partial emergency reservoir evacuation and for required flow releases during reservoir filling. Use of this low level outlet at maximum reservoir level, El. 350, would be restricted to operation with only one gate, due to high energy levels in the expansion chamber. Operation with all three gates open would be restricted to below El. 325.0, with a maximum capacity of 330 m^3/s.

As the low level outlet would be operational prior to closing the north diversion tunnel, release of water would not be interrupted during close of the north tunnel and filling of the reservoir.

ii) Intermediate Level Outlet

The intermediate level outlet would be used to maintain minimum downstream river flows, to permit emergency partial reservoir evacuation and to make service spillway releases. Water would flow from the intake located at El. 282 into an inclined shaft leading to the right diversion tunnel. The outlet would have a capacity of 790 m^3/s at El. 350.0 and would be operable up to that reservoir level.

iii) Auxiliary Spillway

The auxiliary spillway together with the intermediate level outlet would be able to pass approximately 60% of the PMF with the reservoir level at El. 348. The auxiliary spillway would have two 17.0 m wide x 13.8 m high radial gates on a low ogee crest, leading to a 400 m long chute. The chute would terminate in a flip bucket structure designed to throw the flow into the river channel 250 m and 350 m downstream of the embankment toe. The capacity of this spillway would be 3550 m^3/s with the reservoir level at El. 348.0 and 4670 m^3/s at El. 350.0.

iv) Fuse Plug Spillway

The fuse plug spillway (Fig. 3-12) would be located in a rock cut at the right end of the saddle dam. It would be designed to discharge that portion of the PMF that could not be handled by the combination of the auxiliary spillway and intermediate outlet. The fuse plug would wash out when the reservoir level exceeded the fuse plug crest at El. 349.0. It is expected that during the life of the dam the fuse plug spillway would not be used since a storm large enough to wash out the fuse plug would have a return period in excess of 1000 years. The maximum reservoir level during passage of the PMF would be El. 350.0 m. The fuse plug spillway would be 70 m wide and have a capacity of 2690 m^3/s at reservoir El. 350.0.

Operating criteria would be established for routing major flood events such that if a flood of sufficient magnitude occurred to activate the fuse plug, total outflow would be controlled by the spillway and outlet gates such that the maximum overflow for the event would not at any time exceed the peak rate of inflow to the reservoir.

v) Gas Saturation

Free fall type spillways, similar to those proposed for the Stikine River projects, are proposed for the More Creek and Iskut Canyon projects. For the same reasons as discussed for the Tanzilla project gas supersaturation levels just downstream of the Iskut Canyon powerhouse are expected to be about 110%.

f) Power Facilities

The power facilities are shown on Fig. 3-16. Water for power generation would be drawn from an approach channel excavated into the left bank. The intake would be free standing and lead into a 800 m long 13.0 m diameter unlined power tunnel. A surge shaft would be provided at the downstream end of the power tunnel above the penstocks. Just downstream of the surge shaft the power tunnel would feed into 3-5.3 m diameter concrete lined penstocks. Within 40 m of the powerhouse and in the vicinity of the valve chamber the penstocks would reduce in diameter to 4.9 m and be steel lined. Each penstock would supply water to the 270 MW units located in the underground powerhouse. Water would be returned to the river through individual tailrace tunnels.

g) Reservoir

Reservoir slope studies have not discovered any significant problem areas within the reservoir. A normal amount of beaching and minor slumping is expected.

Table 3-3 shows the proposed operating levels of the reservoir. In general the reservoir would be full in November and be drawn down through the months of December to April at which time the reservoir would begin filling again.

The reservoir clearing standards would be the same as those set out for the Stikine River projects.

h) Access, Construction Facilities and Considerations

Preliminary layouts of the access and construction facilities are shown on Fig. 3-17 and Fig. 3-18.

The area terrain dictates that the permanent project access road to Iskut Canyon would be constructed from Highway 37, in the vicinity of Bob Quinn Lake, along the south side of the Iskut River, a distance of approximately 44 kilometres. The permanent access roads would comply with Ministry of Highway specifications. Extensive rock work, taking up to 2 years to complete, would be required on a section of this road. During this period a temporary by-pass road would be constructed on the gravel bars of the Iskut River below the future reservoir level, to provide access to the project. As it is anticipated that this temporary road would be subject to short term closures due to slides or washouts, a temporary airstrip would be constructed at the project to alleviate the problems caused by restricted access.

A 1500-person B.C. Hydro single labour camp would be located approximately 2 km south of the saddle dam in an area of good soil cover, bordering the basalt lava flats.

A 900-person townsite would be located approximately 3 km downstream of the powerhouse on the south bank of the Iskut River also off the lava flats.

B.C. Hydro offices, buildings and storage area together with the contractor's work areas would be located on the lava flats, with the exception of some work areas in the vicinity of the damsite.

The batch plant facilities and aggregate stockpiles would be located adjacent to the powerhouse access. The aggregate and granular material for the embankment dam would be obtained from Area 7 on Forrest Kerr Creek, approximately 3 km upstream of the damsite. Area 7 would be flooded by the reservoir when the project is completed.

The impervious core material would be obtained from Area 4A adjacent to the Ningunsaw River near More Creek approximately 40 km away. The haul road would be largely on the main access road. The rockfill for the saddle dam would be obtained from previously excavated rock and from a quarry adjacent to the saddle dam, which would ultimately become the fuse plug spillway.

All unusable excavated material would be spoiled below the future reservoir level.

All electric power for construction would be diesel generated on site. A storage capacity of up to 4 million litres of fuel would be required for electricity generation and for all other construction activities.

i) Construction Schedule

Construction of the Iskut Project would take 7 years. Assuming that the first contract is awarded on 1 January of year 1, the in-service dates would be

Units 1 & 2	1 Oct of year 7
Unit 3	1 Dec of year 7

Reservoir filling would commence on 15 April of year 7 and would be sufficiently filled by July for commissioning of the units.

3.2.5 MORE CREEK PROJECT

a) General Description

The More Creek Project would be located in a steep-walled bedrock canyon 2 km upstream from the confluence of More Creek and Iskut River. The general arrangement is shown on Fig. 3-19. The featured project arrangement consists of an arch dam constructed across More Creek and underground power facilities located within the left abutment.

b) Diversion

A single shotcrete lined tunnel in the left abutment would be provided for diversion (see Figs. 3-19 and 3-20). The tunnel would be horseshoe shaped, 7.0 m in diameter, and 290 m long. Both the intake and the tunnel would have free-surface flow regimes at design flow. The invert of the tunnel exit portal would be set near the channel bed level, about 5 m below the tailwater level at design flow.

A 20 m high upstream cofferdam built to elevation 426.0 m would enable flows with return periods up to 1 in 10 years to be passed without overtopping the cofferdam. A small downstream cofferdam would be required for construction of the dam.

Diversion would commence by 1 November of the second year of construction and all flows would be passed until construction of the dam was complete. Closure of the diversion tunnel is scheduled to commence November 1 of the 5th year of construction. Filling would be expected to take from 280 to 350 days with no water released during the filling period.

c) Dam

The dam proposed as shown on Figs. 3-19 and 3-20 is a 145 m high thin double curvature, three center arch. The dam would have a crest length of about 360 m. The thickness would vary from 4 m at the crest to 15 m at the base.

The dam would have a 3 m freeboard above the normal maximum reservoir level of El. 535. The maximum flood level El. 538 would be at the crest of the dam, with no freeboard provided.

d) Hydraulic Structures

All outlets for flood protection and service releases would be located within the arch dam. Five 3.4 m diameter jet-flow gates (Fig. 3-20) would be provided. Three would be located at El. 435 m and two at El. 415 m. These gates would have a total capacity of 1650 m^3/s with the reservoir at El. 535 and 1670 m^3/s at El. 538 m.

The jets from these outlets would land in the river channel at a relatively flat angle between 60 m and 120 m from the base of the arch dam. A plunge pool would be created for dissipation of the energy of the jets by a weir constructed downstream of the impact location.

Although it is planned that no water would be released during the filling of the More Creek reservoir, emergency flows could be released from the lowest jet flow gates during reservoir filling. If the flow in the Iskut River became dangerously low due to an extremely dry year, More Creek flows could be released to supplement the flow in the Iskut River to meet the minimum downstream flow requirements once the reservoir level has been raised above El. 415. In a dry year, it is expected that the reservoir would fill to this level in a matter of days after closure.

e) Power Facilities

The power facilities consist of an intake, two penstocks and an underground powerhouse located within the left abutment. The penstocks would be about 340 m long, the majority of which would be concrete-lined at 3.9 m diameter with a short steel-lined portion to the units at 3.5 m diameter. The powerhouse would contain two 85 MW units. A 40 m long tailrace tunnel 6.0 m wide x 9.3 m high would be constructed downstream of a tailrace manifold.

f) Reservoir

Reservoir slope studies have indicated a potentially unstable slope exists upstream of the damsite.

The basic data concerning the reservoir is shown on Table 3-3. In general the reservoir would be full in November and be drawn down through the months of December to April at which time the reservoir would begin filling again.

The inundated areas would consist of unimproved valley slopes. The clearing standards used for More Creek would be identical to those used at Iskut Canyon.

g) Access, Construction Facilities and Considerations

Preliminary layouts of the access and construction facilities are shown on Fig. 3-17 and Fig. 3-21.

The 13 km permanent project access road would join Highway 37 just north of Bob Quinn Lake.

A 600-person B.C. Hydro single labour camp would be located on the left bank of the Iskut River, which would separate it from the work areas. Where More Creek joins the Iskut River there is a large river flat which could accommodate the B.C. Hydro facilities and contractor's work area.

A 900-person townsite would be located near the proposed road function north of Bob Quinn Lake. This would be permanent for use during the operating period and some residence by families not connected with the projects is anticipated.

A radial cableway could be used for placement of the concrete for the arch dam. The batch plant facilities and aggregate stockpiles would be adjacent to the trackway. All aggregate would be obtained from the More Creek gravel bars 1.5 km upstream of the dam. A second batch plant would be located adjacent to the powerhouse for the concrete required for the powerhouse, tailrace, switchyard and miscellaneous structures.

Spoiling would be below the future reservoir level where possible. A spoil area has also been located 0.5 km north of the project.

A storage capacity for up to 1 million litres of fuel would be required to accommodate electricity generation and construction activities.

h) Forrest Kerr Creek Diversion Dam

The Forrest Kerr Creek would be diverted across the divide to the More Creek watershed by a 50 m high embankment dam with a central impervious core and gravel shells. Figs. 3-22 and 3-23 show the proposed diversion scheme. The crest length of the dam would be about 190 m.

Diversion during construction would be by a 5.5 m diameter shotcrete lined tunnel, 190 m long located in the left abutment. An upstream cofferdam about 14 m high would be constructed of dumped rockfill with a dumped impervious blanket. The diversion tunnel would be plugged upon completion of the dam.

Apart from the diversion dam across the Forrest Kerr Creek no other permanent facilities would be required and permanent access to this site would not be necessary.

The diversion route over the divide between the Forrest Kerr Creek and More Creek watersheds is flat over a distance of about 1 km with a maximum rise to about El. 560. As only minor channel improvements would be made and diversion flows would be expected to follow the natural contours to reach the channel of More Creek, a maximum diversion pool level of El. 562.5 is expected under extreme flow conditions. The dam crest would be at El. 570, giving a 7.5 m freeboard allowance. Under normal flows the diversion pool would be lower than El. 562.5 and in the course of time, with some diversion channel erosion, the diversion pool may be lowered further. It is expected that the diversion pool would fill with sediment about 40 years after completion of the diversion. Thereafter, sediment loads would be carried into More Creek.

The same clearing standards applied to the Iskut Canyon and More Creek projects would be applied to the Forrest Kerr Diversion pool and channel.

h) Construction Schedule

Construction of the More Creek Project would take 6 years. Assuming the first contract is awarded on 1 January of year 1, the in-service date for units 1 and 2 would be 1 October year 6. The downstream weir would be completed by 31 December, year 6. Reservoir filling would commence on 1 November year 5 and the reservoir would be above the minimum reservoir level by mid July.

Construction of the Forrest Kerr Creek Dam is estimated to take three seasons; one for the access road, one for preparatory work and one for dam construction.

3.2.6 OPERATION

a) Proposed Operation

i) General

The operation of the plants would be determined by the following constraints:

a. available flows for power generation,
b. minimum environmentally acceptable flows downstream of plants,
c. power demand,
d. maximum acceptable rates of flow and stage changes downstream of plants.

ii) Available Flows for Power Generation

The available flows for power generation would be dependent on natural streamflows in the river, reservoir power storage available for regulation and total installed capacity of the plant.

Based on 40-year period of synthesized historical data, the monthly average natural streamflows in the Stikine River at the project sites range from lows of about 30m³/s in March to highs of over 1000 m³/s in June. Estimated average annual flows are 290 m³/s and 295 m³/s at the Stikine Canyon and Tanzilla sites respectively.

The monthly average natural streamflow in the Iskut River at Iskut Canyon, ranges from a low of about 30 m³/s in February to a high of over 700 m³/s in July. The minimum flow recorded was 16.8 m³/s and occurred on 5 march, 1972. The monthly average natural streamflow in More Creek, ranges from a low of 5 m³/s in March to a high of 130 m³/s in July. Estimated average annual flows are 250 m³/s and 70 m³/s at the Iskut Canyon and More Creek sites respectively.

Preliminary economic analysis and power studies have indicated the following optimum installed capacities, reservoir levels and power storage:

	Stikine Canyon	Tanzilla	Iskut Canyon	More Creek
Installed capacity (MW)	960	960	810	170
Max. Normal reservoir level (m)	794	531	347	53[illegible]
Minimum reservoir level (m)	749	529.5	312	493
Operational drawdown (m)	45	1.5	35	42
Power storage (million m³)	4300	10	900	1500

Natural streamflows in summer are much greater than the plant capacities and in winter the natural flows are much lower than the plant capacities. In order to increase the utilization of the total river flow, excess water in the spring, summer and fall would be stored in the reservoirs. During the period of low winter flow the stored water would be used for power generation. The only exception is the Tanzilla plant. As the fluctuations of the natural flow regime are already damped by the storage of flow in the Stikine Canyon reservoir, no further regulation of annual flows is necessary in the Tanzilla reservoir. Therefore no appreciable power storage is provided in the Tanzilla reservoir.

During very high run-off years, when the volume of natural flow into the reservoirs exceeds the storage volume available, excess water will have to be spilled from the reservoirs in the summer. This would happen an average about 3 years in every 5 for the Stikine River Projects, once every 2 years for Iskut Canyon and three times in 10 years for More Creek Project. Based on the available streamflow data, the Stikine Canyon and Tanzilla projects would be expected to utilize about 96 percent of the average annual natural flow passing the project sites for power generation, while the Iskut Canyon project would utilize 97% and More Creek 98%.

iii) Minimum Downstream Flows

Based on an analysis of natural streamflows and minimum acceptable fish habitat requirements recommended by Tennant (1976) the following criteria for the minimum downstream flows have been provisionally adopted:

October - March: 10% of the average annual flow

April - September: 30% of the average annual flow

The low level outlets provided at Stikine Canyon, Tanzilla and Iskut Canyon would permit the minimum flows indicated above to be maintained during reservoir filling. Once the powerplants were in operation the power releases would normally maintain the downstream flows above the minimum requirement. In the event of a loss of the transmission lines (estimated to happen once in 10 years) or the tripping out of all operable units, discharge immediately downstream of the powerhouse would be cut off. To minimize the effects of this flow interruption provision would be made for the immediate opening of a service outlet at the dam by an operator to restore minimum flows. Because of the distance from the dam to the powerhouse tailrace it would take 1/2 hour to 1 hour for the flow to be fully restored at the powerhouse. Further downstream the effects of the flow interruption would be lessened by tributary inflow and the moderating effect of the distance on changes in the flows released at the powerhouse.

Because of the close proximity of More Creek to the Iskut River, with its continuous flow of water, no minimum flow would be maintained in More Creek below the dam. If during the filling of More Creek unusually low flows in the Iskut River would cause the flows in that river to be below the minimum requirements discussed above, water could be released from the lowest outlet in the More Creek dam to maintain the minimum flows.

iv) Power Demand

B.C. Hydro provides electricity to the province wide electrical power grid in response to demands for power from its customers. This demand varies on an annual basis from low levels in the summer to peaks in mid-winter, and on a daily basis from lows in the early morning hours to peaks in mid morning and early evening. Electricity is drawn from all of B.C. Hydro's sources to fulfill the instantaneous demand, subject to particular constraints at each source.

The Stikine-Iskut projects would be used to generate electricity for the provincial grid in combination with other hydro plants. Ideally these projects could be best utilized if they had the flexibility to be operated as necessary, without constraints, to meet the system demand requirements.

v) Maximum Acceptable Rates of Change of Stage

Environmental studies have indicated that the downward rate of change of river stage could be the most significant hydrological impact of the proposed development. A downward rate of change not exceeding 150 mm in 6 hours was assumed to be the maximum environmentally acceptable rate.

Several methods of operating the Stikine Canyon and Tanzilla projects have been considered. These could reduce the rate of reduction of discharge from the Tanzilla plant and still meet the system power requirements.

Preliminary studies indicate that the rate of downward stage change in the Iskut River downstream of the station "Iskut River above Johnson River" due to unrestricted operation would be higher that the assumed acceptable rate. Restrictions would be required on the rate at which units could be taken off line and shut down to limit the rate of change of the stage at this location due to operation of the Iskut powerplant.

b) Downstream Flows

i) General

The proposed operation of the projects would modify the flow regime of the rivers from the reservoirs to the estuary. In relative terms the degree to which flows would change would decrease progressively further, downstream. As one progresses downstream, tributaries rising in areas which have higher runoff per unit area and which have a different seasonal pattern of runoff increasingly contribute to the river flows masking the effects of regulation.

Flows originating above the Forrest Kerr Creek Diversion would be entirely diverted into More Creek, reducing flows in Forrest Kerr Creek downstream from the diversion structure to the minor contribution of streams entering between it and the area flooded by the Iskut Canyon project. The large size of the More Creek reservoir would allow the storage of all inflows from May through July. This would cut off flows in More Creek between the More Creek dam and the confluence with the Iskut River (about 1 km).

ii) Average Downstream Flows

A forty year mean monthly data set of inflows beginning in 1940 and ending in 1981 was used to derive a set of mean monthly power releases from the projects.

In order to calculate daily flows under operating conditions at downstream points, incremental flows between projects and downstream gauging stations were added to the releases from the projects.

The effect of regulation generally would be to shift flow from the summer months to the winter months. Releases would on average be higher than natural in all months from October through April and lower than natural from May through September. Consequently, average flows at all downstream points will be higher in winter and lower in summer than under natural conditions. In most years, the reservoirs would fill by July. The reservoirs would be held near the full elevation until November or December. During this period (Sept-November) the flows released would be very near the naturally occurring flows, as would the flows occurring at downstream points. These points are summarized below as follows:

Stikine River Average Flows
(m^3/s)

	Stikine Canyon		Telegraph Creek		Butterfly Creek		Wrangell	
	Nat.	Regul.	Nat.	Regul.	Nat.	Regul.	Nat.	Regul.
Jan-April	33	340	67	370	100	400	330	610
May-July	750	230	1020	500	1500	960	3200	2600
Aug-Oct	340	330	420	420	820	820	2500	2500
Nov-Dec	90	280	120	300	200	380	630	800

Average Flows
(m^3/S)

	Iskut Canyon		Iskut @ Johnson		Stikine @ Wrangell	
	Natural	Regulated	Natural	Regulated	Natural	Regulated
January	35	172	74	210	384	473
February	30	207	63	240	302	453
March	31	253	57	281	223	441
April	51	230	121	294	412	577
May	256	196	445	363	1670	1630
June	675	200	989	467	3870	3200
July	726	462	1130	842	3930	3770
August	578	486	983	879	3300	3210
September	379	370	653	647	2260	2270
October	290	345	569	576	1870	1960
November	133	203	236	296	930	913
December	58	172	107	220	336	493

iii) Short-Term Flow Variations

The projects would not operate at a constant output even over as short a period as a day. Some variation would occur as the plants responded to varying demand for power.

3.3 TRANSMISSION PROJECT

3.3.1 SYSTEM ASPECTS

Current engineering studies indicate that considering the amount of power to be transmitted, the distances involved and the projected costs, three 500 kV alternating current transmission lines would be the most economical and technically sound plan to transmit the electrical power from the Stikine-Iskut generating sites to the system grid.

The transmission system presently proposed is shown schematically in Fig. 3-24 and consists of the following:

- two 500 kV lines from each of the proposed Tanzilla and Stikine Canyon generating sites to a collector station near Stikine Canyon (Stikine Collector). Two 500 kV lines would carry power south from the Stikine Collector to another collector station in the vicinity of Bob Quinn Lake (Bob Quinn Collector).

- two 500 kV lines from the proposed Iskut Canyon generating site and one 230 kV line from More Creek generating site would also connect to the Bob Quinn Collector station.

- three 500 kV series compensated lines would then carry power south from the Bob Quinn Collector to the existing system grid at Telkwa substation, near Smithers.

Transmission system expansion requirements in both the Central Interior and Lower Mainland regions (as affected by the Stikine-Iskut development) continue to be assessed in accordance with changes in load forecasts and generation sequences. Ultimately, additional transmission would be required to support the existing 500 kV system between the Prince George area and the Lower Mainland and to carry some of the power from the Stikine-Iskut development to load centres in the south of the province. The system expansion currently projected is shown in Fig. 3-24 and includes the following 500 kV transmission lines:

- two lines from Glenannan substation near Vanderhoof to a proposed Dash Creek substation, approximately 80 km west of Clinton.

- one line from Dash Creek substation to Kelly Lake substation, near Clinton, and one series compensated lined from Dash Creek substation to Meridian substation in the Lower Mainland.

The above transmission requirements assume the existence of:

1. a second 500 kV circuit between Williston substation near Prince George and Telkwa substation near Smithers; this second circuit will be required to provide firm supply for load growth west of Prince George long before the Stikine-Iskut development is constructed.
2. the Peace Site C project which includes construction of a third Williston - Kelly Lake 500 kV line and a second Kelly Lake - Cheekye 500 kV line.

As transmission system expansion requirements are based on the location and magnitude of future electricity demand, they are indefinite at this time and have not been evaluated in this Interim Assessment Report. However, cost estimates for currently projected system transmission related to the Stikine-Iskut development have been included in Section 4 of this report. The route description for the proposed development (Section 3.3.2) deals only with the transmission lines required to connect the Stikine-Iskut generating sites to the electric grid.

3.3.2 ROUTE DESCRIPTION

In Section 2.2, the process employed to select the preferred corridors is detailed. Once these corridors have been established, the normal practice for route selection is to initially identify the most technically feasible route. This is accomplished by means of detailed field investigation and preliminary surveys. As environmental considerations have to be factored into the route choice, an iterative process utilizing both technical and environmental input is used to arrive at the best possible compromise solution.

Since detailed technical and environmental studies were prematurely curtailed (because of deferral of the project), the route described hereunder has not been optimized in terms of technical and environmental considerations. Rather, the discussion is based on a preliminary technical route preference determined from air photo interpretation, photogrammetric mapping and preliminary field review. the precise right-of-way location cannot be determined until centreline survey is carried out. Fig. 3-25 shows typical right-of-way widths for two and three 500 kV lines on flat terrain. The distance between transmission towers would average approximately 400 metres.

The proposed route (as shown in Fig. 1-1) generally follows Highway 37 south to the Skeena River and Highway 16, and continues its southerly course passing to the west of Hudson Bay Mountain to Telkwa Substation located approximately 373 km south of Bob Quinn Lake.

(a) Tanzilla Powerhouse to Stikine Collector

The route distance between the Tanzilla site and the Stikine Collector is approximately 25 km. The route would leave the Tanzilla generating site from the powerhouse located approximately 7 km downstream of the damsite. The route begins on a steep incline near Stikine River level at elevation 275 m and climbs a series of lesser inclines to the Klastline Plateau at elevation 1050 m. It then traverses relatively flat terrain and terminates at the proposed Stikine Collector site located approximately 4 km south of the Stikine Canyon generating site. The terrain at the start of the route is rocky with medium tree cover which thins out on till material across the plateau where a forest fire has destroyed most of the timber. There is no existing access to this area. Access to most of the route would be provided by the proposed access road to the Tanzilla generating site.

(b) Stikine Canyon Generating Site to Stikine Collector

The route heads north from the Stikine Canyon powerhouse and spans the box canyon and spillway to the north side of the Stikine River. It then crosses the Stikine River canyon and traverses easy terrain south across the Klastline Plateau to the Stikine Collector. The terrain is predominantly rock on the north side and glacial till on the south. Access would be provided to both sides of the river via the earthfill and concrete arch dams.

(c) Stikine collector to Bob Quinn Collector

The route distance between the Stikine Collector and Bob Quinn Collector is approximately 139 km. The route heads southeast from the Stikine Collector and drops down to a flat portion of the Klastiline Plateau which is characterized by intermittent swamps and light tree cover. It then crosses the Morchuea and Tsaybahe creeks and climbs to higher terrain crossing Highway 37 approximately 8 km north of Iskut village. There is no access throughout this portion of the route. The route continued along easy terrain through light tree cover to the east of the Iskut airstrip and Iskut village. It then turns south and shares a narrow corridor with Highway 37 through heavy deciduous forest along the base of Mount Ehahcezetle. Here, steep sideslopes, unstable terrain and avalanches are typical for approximately 5 km. The route then crosses Coyote Creek and turns southwest, passing a B.C. Highways maintenance yard before entering the narrow Todagin Creek valley. Highway 37 also runs along this valley and is crossed by the route twice because of steep terrain near the highway. Terrain throughout this area is rocky and steep with medium forest cover. The route then crosses Todagin Creek, and passes between a ranch and the highway then leaves the highway to reduce the visibility of the line from Kinaskan Lake and an adjacent park reserve. The terrain remains rocky but becomes rolling with flat areas and intermittent swamps between the Iskut

River and the Mountain range to the east. The route is located at the base of the mountains to ensure better tower footings than would be the case in the swampy areas. Forest cover in this area is medium until the route crosses Burrage Creek where there is an extensive burn area for approximately 25 km to Devil Creek. To reduce visibility, the route has been located away from Highway 37 throughout this area. The route then crosses the highway and parallels Devil Creek, then turns southeast to terminate at the proposed Bob Quinn Collector site. This section of the route is heavily treed and avoids the potential recreational development in the vicinity of Bob Quinn Lake. The extent of the development may preclude the use of this area for a station site, however, it is important that the power be collected in this general area to minimize the overall transmission line length.

(d) More Creek to Bob Quinn Collector

The route distance between the More Creek generating site and the Bob Quinn collector site is approximately 11 km. A 230 kV single circuit transmission line supported primarily by wood pole structures is required to transmit More Creek power. The distance between structures would average approximately 200 m, depending on terrain. The required right-of-way width would be about 30 m over most of the route.

The route leaves the More Creek generating site at a point 1 km west of the More Creek-Iskut River confluence. It then spans More Creek and the Iskut River and traverses easy terrain through heavy tree cover to Bob Quinn Collector. Access to this section of line would be provided by the proposed permanent access road to the More Creek generating site.

(e) Iskut Canyon to Bob Quinn Collector

The route distance between the Iskut Canyon generating site and the Bob Quinn collector is approximately 39 km. The preferred route leaves the Iskut Canyon powerhouse site 1.5 km downstream of the damsite, heads west over a small rise then across the lava flats behind the secondary damsite and runs parallel to a proposed temporary airstrip. It then turns north up the Iskut valley and crosses the reservoir, spanning a bay at the outlet of Tom MacKay Creek. Towers would be placed on either side of the bay to avoid avalanches which cascade off the mountain immediately east of Tom MacKay Creek. The route then climbs steeply from elevation 450 m to a sparsely treed bench at elevation 1200 m, turns and heads north. The route follows this bench to a point halfway up the valley where it parallels the proposed dam access road to Bob Quinn Collector.

(f) Bob Quinn Collector to Telkwa

The route distance between the proposed Bob Quinn Collector and Telkwa substation near Smithers is approximately 373 km.

The first 30 km of the route, from Ogilivie Creek to the Bell-Irving River, follows a valley characterized by hanging glaciers, steep mountain slopes and numerous avalanche zones, making it the most technically difficult section of the transmission project. Earlier studies examined a route for one single and one double 500 kV circuit through this valley. To avoid the use of a double circuit, it was decided to examine a route for three 500 kV single circuits using photogrammetric mapping techniques. This examination is complete, but a ground survey would have to be conducted to confirm the technical feasibility of the route.

The route heads southeast from the Bob Quinn Collector across level, heavily wooded terrain for 5 km, turns east and crosses Highway 37 on the north side of Echo Lake. Visibility of this crossing may be reduced by using the high ridge on the east to raise the conductors well above the road. The route continues along this ridge until it converges with Highway 37 halfway between Ogilvie and Alger Creeks. Through this section the highway borders the Ningunsaw River while the route traverses the rugged terrain above. This area is an avalanche hazard area, however a possible route has been identified where towers would be located on elevated ridges between the avalanche chutes. The selection of the route between Ogilvie and Alger Creeks was based on determining the best technical route while avoiding the Bob Quinn Ecological Reserve No. 59. The Ecological Reserve is 2047 ha in area and is bordered on the north and east by the Nignunsaw River. It is possible that the ground surveys discussed earlier will show that a route with acceptable security for three 500 kV single circuit transmission lines cannot be built through this area. If this is the case a route through the Ecological Reserve may have to be considered.

The route proceeds southeast through heavy timber on the east side of the valley above Highway 37 just beyond Liz Creek where it turns south and crosses to the west side over Beaverpond Creek and the highway to avoid avalanche zones. The terrain is steep with dense forest stands which will likely reduce the visibility of the lines from Highway 37 which the route parallels for the next 7 km. The route is again forced across Highway 37 to avoid avalanche zones and then is confined for the next 7 km to the valley bottom by massive avalanche zones on both sides. Here, the route follows a swampy areas shared with Snowbank Creek and the highway. It then climbs the east side of the valley to avoid the largest avalanche zone in the area before heading into the Bell-Irving valley. Avalanches in this area affect the highway approximately once every three years.

The precise location of transmission lines would be governed by the selection of secure tower sites. In some cases it may be necessary to place towers in avalanche hazard zones and provide protection for them.

As the route leaves Snowbank Creek it enters the wide Bell-Irving valley crossing gently rolling terrain. Forest cover is relatively constant throughout with intermittent logging occurring in areas close to the highway. The route crosses Highway 37 and the Bell-Irving River about 3 km downstream of the Bell II highway bridge. Tower sites in this area may require protection against river erosion. The route continues over a hill and crosses the east side of the highway where it remains for the next 212 km. The area is characterized by heavy forest cover and occasional rock outcrops. The route is located approximately 1 km east of Highway 37 to reduce its visibility from the highway. The route crosses the major streams of Skowill, Deltaic, Taft and Cousins creeks before crossing the Bell-Irving again about 1 km downstream of the Bell I highway bridge.

The route then traverses around the base of Mt. Bell-Irving to the 800 m level and heads back to parallel Highway 37 to the site of the proposed Meziadin station at 370 m elevation. The currently preferred location for Meziadin Station is approximately 3 km northeast of Meziadin Junction.

From Meziadin station the route descends to a low lying, swampy area and crosses the meandering Hanna and Tintina creeks. It crosses the Nass River and approaches Highway 37 briefly, then for the next 65 km traverses the wide Nass River valley which is characterized by low lying, rolling terrain with scattered swamps, medium forest cover and numerous lakes and streams. There are areas of tree blow-downs in this section indicating that the line could be subjected to high winds. For the last 25 km before rejoining Highway 37 the route is very remote with little existing access. It then enters the narrower valley shared by the Cranberry and Kitwanga rivers and traverses a gentle side slope following the flank of the Kispiox Range to Kitwanga Lake. The route is purposely placed at the lower elevations to reduce its visibility from Highway 37. At Kitwanga Lake the route ascends the higher terrain across the southern end of the Kispiox Range reaching an elevation of 730 m as it passes through a logged-off area and enters the Skeena River valley. At this point the Skeena River, Highway 16 W, and the CN Railway all run along the valley floor, but these can be easily spanned by the transmission lines. On the south side of the Skeena River the route turns a sharp angle west, crosses Juniper Creek and enters the Kitsguecla River valley. This valley is characterized by well-defined creek and river beds and dense forest cover. Access from the south and north is provided by logging roads but there is no access to a 13 km section near Hankin Lake. The route follows the existing access on the east side of the Kitseguecla River for about 10 km, then crosses the river and continues over easy to medium terrain west of Hudson Bay Mountain to the Telkwa River. The route passes through some tall timber areas some distance from Hudson Bay Mountain ski hill avoiding Dennis and Aldrich Lakes and the Pine Creek area. It then descends and crosses the Telkwa River which runs through a well-defined canyon at this point. The river banks are steep with numerous sections of sloughing indicating unstable terrain typical of the glacial till in this area. On the south side of the Telkwa River the route joins the existing 500 kV circuit 5L63 and parallels the line for the next 17 km. From here to Telkwa Substation, a distance of 15 km, the route follows the Bulkley River valley, paralleling the existing 138 kV line 1L385. The terrain from the Telkwa River to Telkwa Substation is gently rolling, lightly treed and generally agricultural, characteristic of the Bulkley Valley. Approximately 7 km south of the point where the route joins 1L385 it crosses the Bulkley River and parallels the Pacific Northern Gas natural gas pipeline almost to Telkwa substation.

3.3.3 SUBSTATION REQUIREMENTS

(a) Stikine Collector Station

A specific site for the Stikine Collector Station will not be determined until the final stages of detailed route selection studies. The approximate minimum size of the fenced in area for the station would be 13 ha based on accommodating the following facilities: six 500 kV lines plus one spare position allowing for transmission lines from three directions; three 500/230 kV transformer positions to allow for 230 kV supply for local loads (at this time it is now known if loads requiring 230 kV transmission would develop in the area); provision for 69 kV supply for local loads at Eddontenajon, Telegraph Creek and Dease Lake; circuit breakers, switching equipment, series capacitors, control building, etc. A relatively flat site on stable terrain will be required. Access to the station would be planned in consideration of requirements for the hydroelectric plant and transmission line facilities.

(b) Bob Quinn Collector Station

As for the Stikine Collector, a specific site for this station will not be determined until detailed route selection is almost complete. The approximate minimum station size would be 20 ha based on accommodating the following facilities: seven 500 kV lines from three directions; one 230 kV line from More Creek plus one spare position for potential local loads, circuit breakers, switching equipment, control building, etc. A flat, stable site will be required; access would be planned in consideration of other development and local requirements.

(c) Meziadin Substation

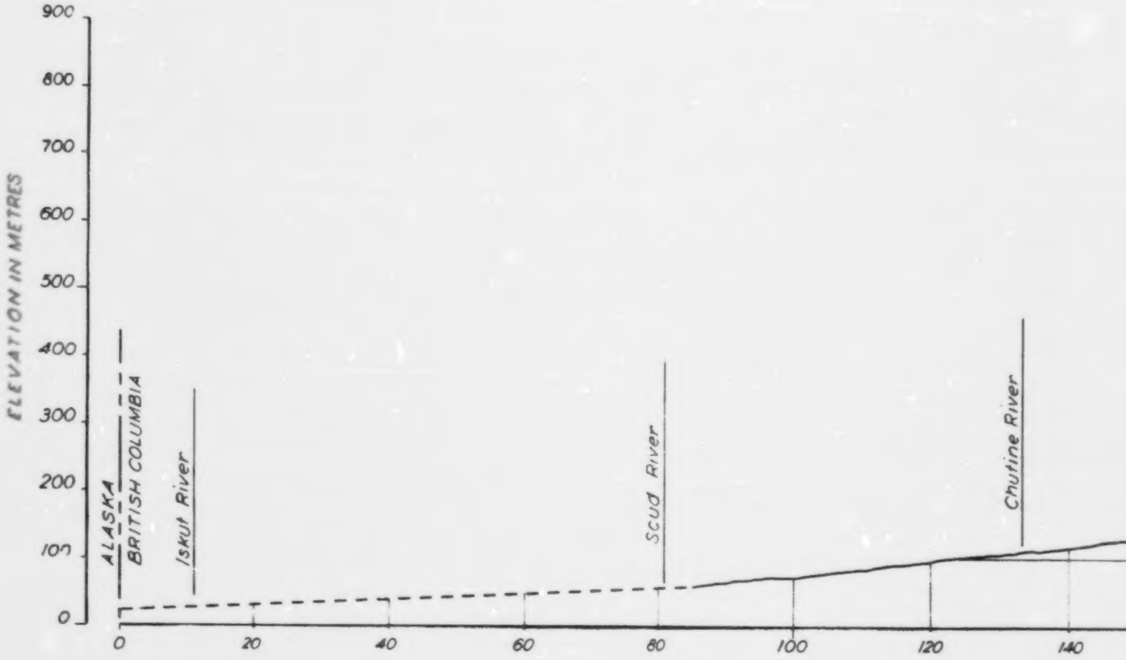
Provision has been made for a substation in the Meziadin area to supply potential loads at Stewart/Meziadin, should they develop. Such a station would loop off one of the 500 kV lines going to the Telkwa Substation from the Bob Quinn Collector. The approximate minimum size of the station would be 3.5 ha assuming the following facilities: three 138 kV transmission lines plus one spare position for supply to Stewart and potential local industrial loads; 25 kV supply for station and local requirements; circuit breakers, switching equipment, etc.

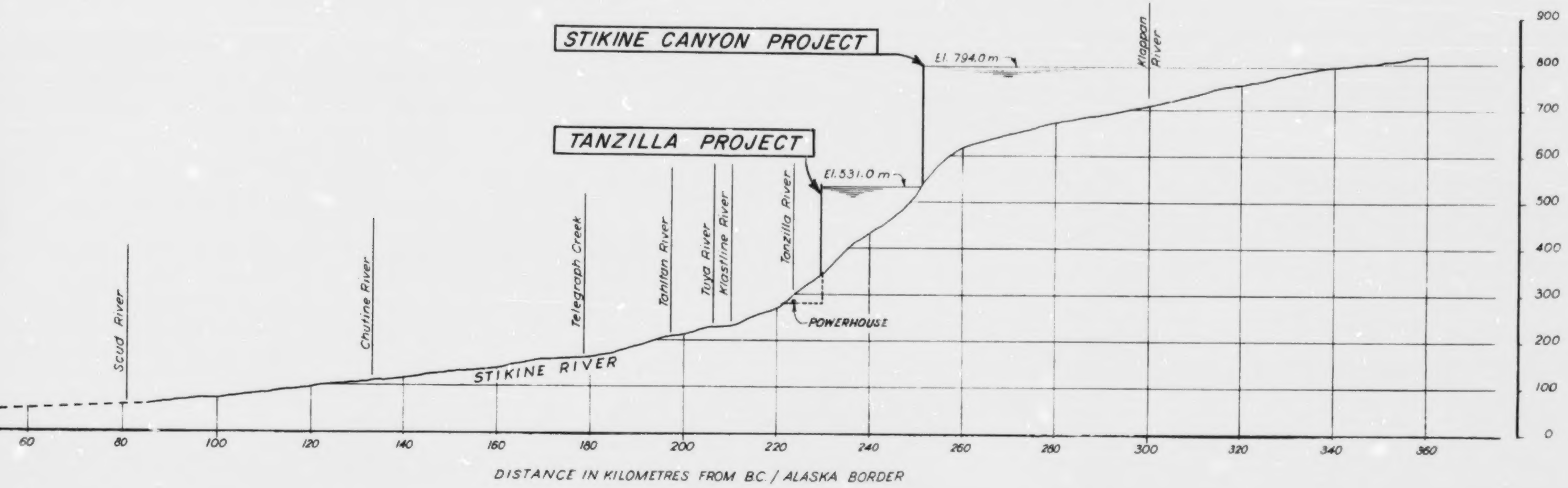
(d) Telkwa Substation

The existing Telkwa Substation has provision for eight 500 kV lines and could therefore accommodate three 500 kV lines from the Bob Quinn Collector Station. Extra space would be required for the installation of reactors associated with these lines and possibly for 500 kV right-of-way to the north-east between the highway and the station.

(e) Capacitor Stations

Some compensation would be required for the three 500 kV lines from Bob Quinn Collector to Telkwa Substation because of the long distance between these stations. It has not yet been decided whether a separate series capacitor station would be located at the approximate midpoint of the line or integrated at one of the two stations. A separate series capacitor station would require approximately 3.4 ha.


ELEVATION IN METRES
900
800
700
600
500
400
300
200
100
0
ALASKA
BRITISH COLUMBIA
Iskut River
Scud River
Chutine River
0
20
40
60
80
100
120
140



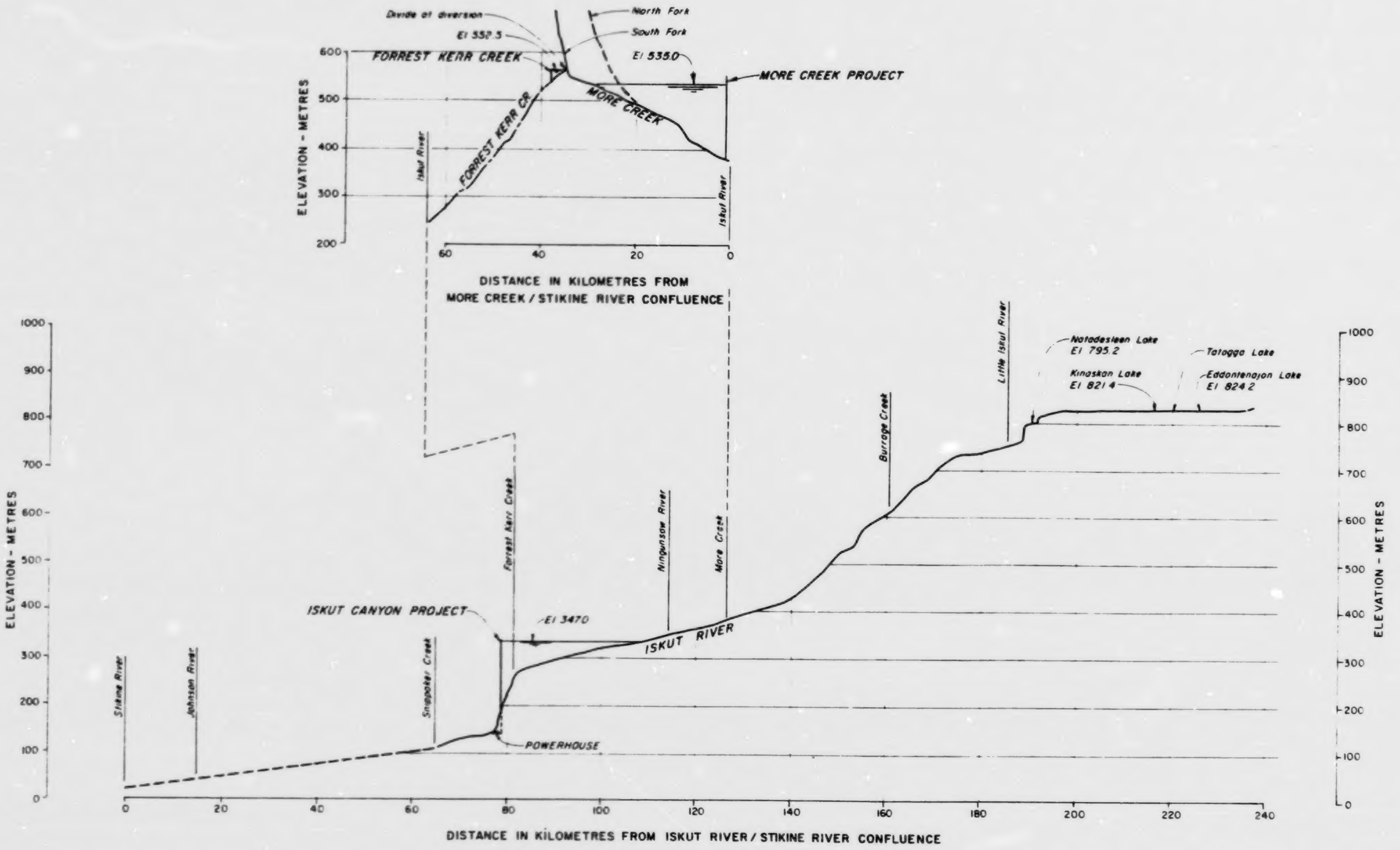
BRITISH COLUMBIA HYDRO AND POWER AUTHORITY

STIKINE - ISKUT DEVELOPMENT

STIKINE RIVER PROFILES SHOWING THE PROPOSED SCHEME OF DEVELOPMENT

DATE DEC 1984	FIG. 3-1
DWN SMD	DWG. No 915-C14-C854

REPORT No. H1720



All dimensions are in metres unless otherwise shown

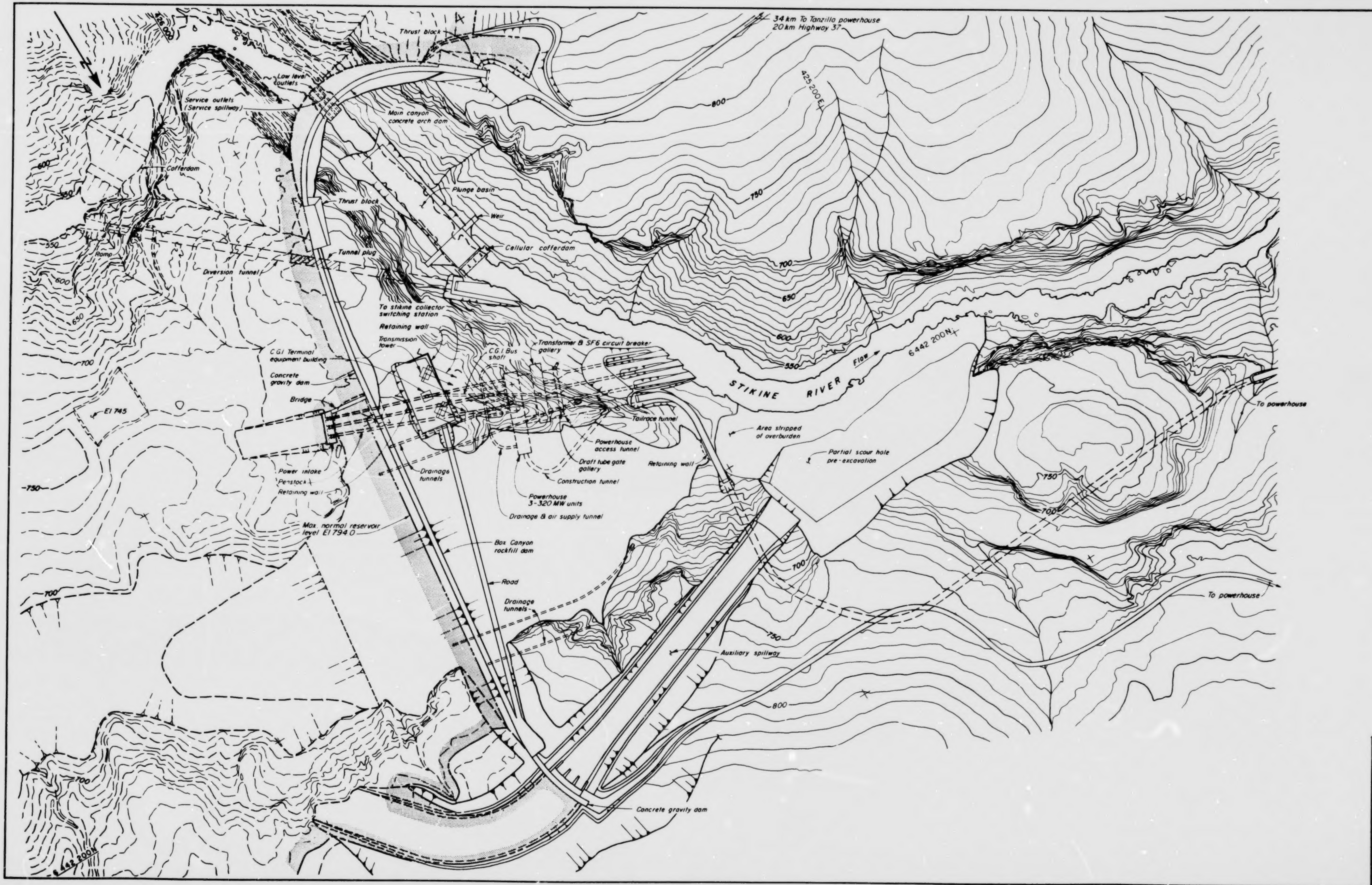
BRITISH COLUMBIA HYDRO AND POWER AUTHORITY

STIKINE - ISKUT DEVELOPMENT - ISKUT CANYON PROJECT

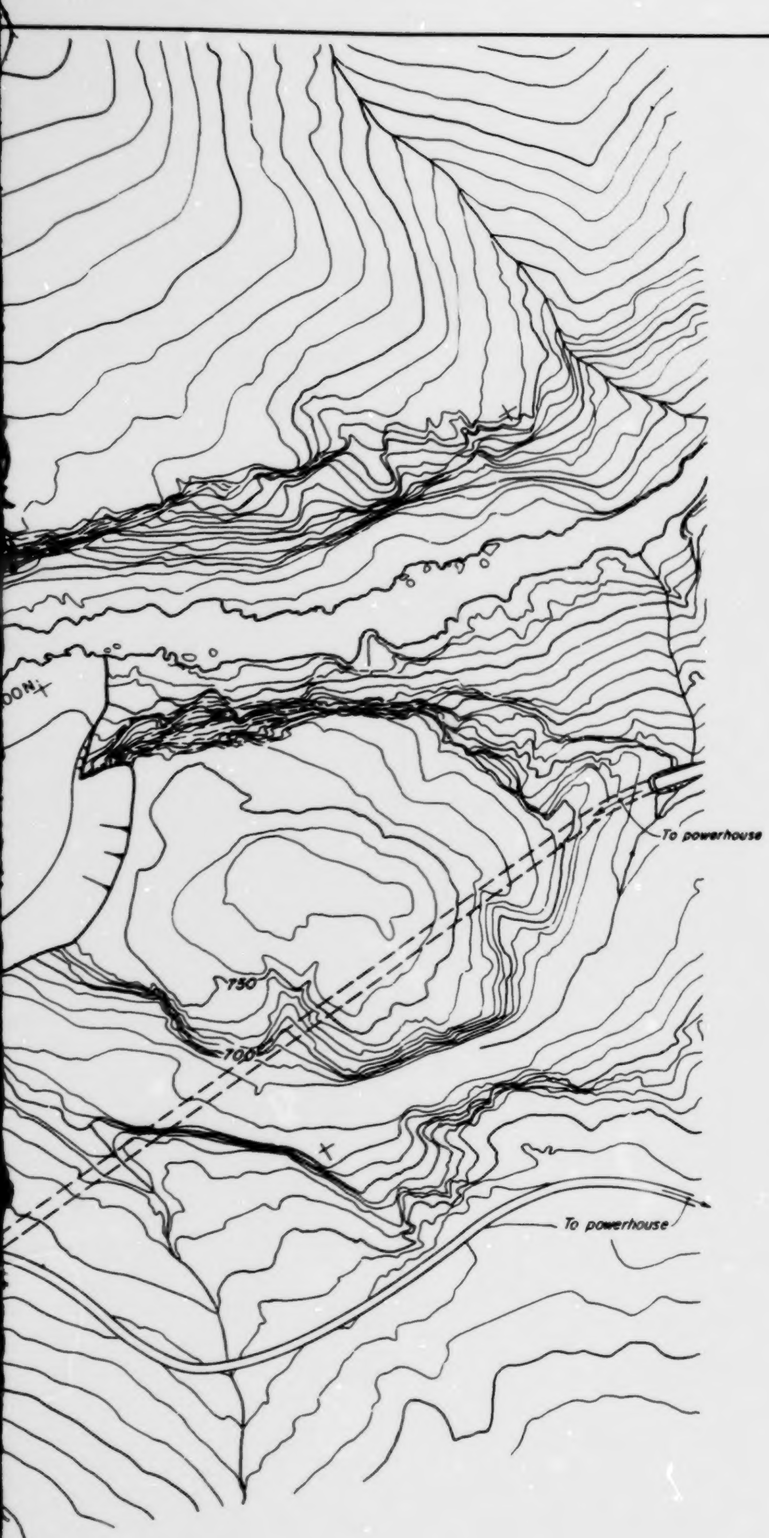
ISKUT RIVER PROFILE SHOWING
SCHEME STUDIED

DATE DEC 1984	FIG. 3-2
DWN. JB	DWG No 913-C14-B459

REPORT No H1720


N
426 000
Thrust block
34 km To Tanzilla powerhouse
20 km Highway 37
Low level outlets
Service outlets (Service spillway)
Main canyon concrete arch dam
800
425 200E
600
Cofferdam
550
Plunge basin
Thrust block
Weir
750
550
Ramp
Tunnel plug
Cellular cofferdam
Diversion tunnel
700
600
650
650
To stikine collector switching station
Retaining wall
600
Transmission tower
C.G.I. Bus shaft
Transformer & SF6 circuit breaker gallery
550
C.G.I. Terminal equipment building
Flow
6 442 200N
700
Concrete gravity dam
STIKINE RIVER
Bridge
El 745
Tailrace tunnel
To powerhouse
Area stripped of overburden
Powerhouse access tunnel
Partial scour hole pre-excavation
Power intake
Draft tube gate gallery
Retaining wall
Penstock
Retaining wall
Drainage tunnels
Construction tunnel
750
-750
Powerhouse 3-320 MW units
700
Drainage & air supply tunnel
Max. normal reservoir level El 794.0
Box Canyon rockfill dam
700
Road
700
Drainage tunnels
To powerhouse
750
Auxiliary spillway
800
700
Concrete gravity dam
6 442 200N

ST
F
G
DATE
DWN
REPOR



To powerhouse
750
700
To powerhouse

Scale: 50 0 50 100 150 200 Metres

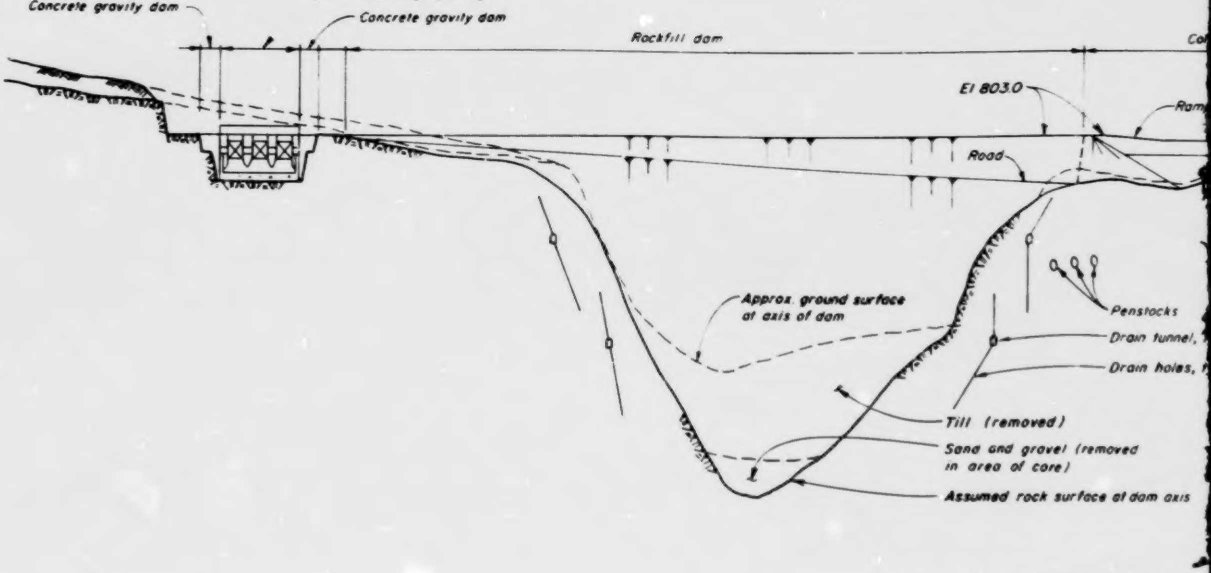
BRITISH COLUMBIA HYDRO AND POWER AUTHORITY

STIKINE-ISKUT DEVELOPMENT-STIKINE CANYON PROJECT

FEATURED ARRANGEMENT LAYOUT Z6
GENERAL PLAN

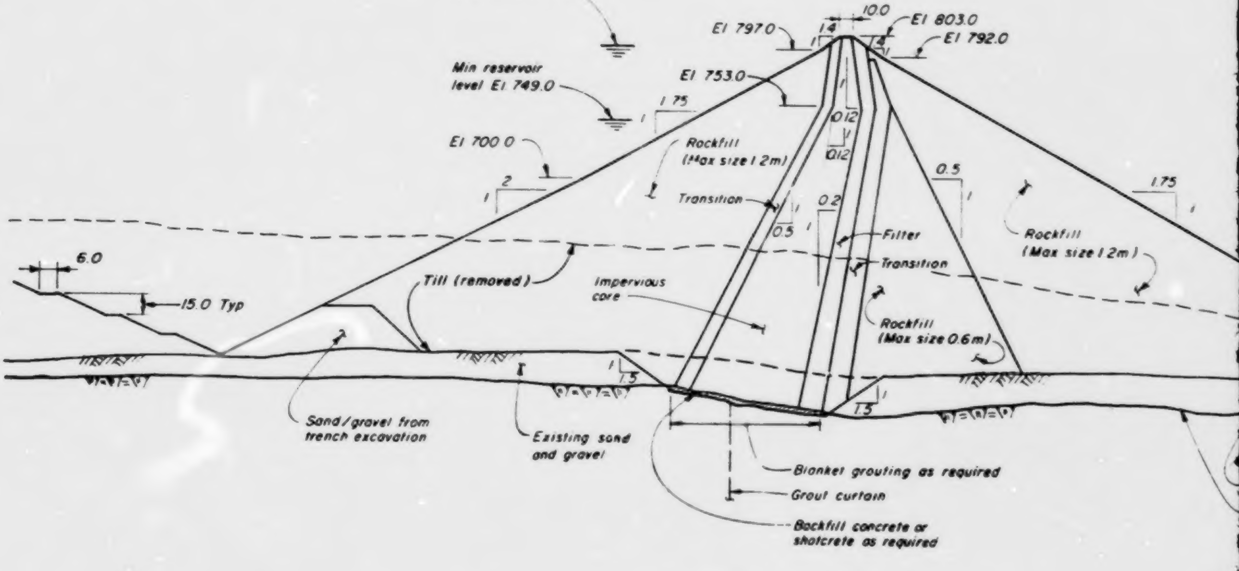
DATE DEC 1984	FIG. 3-3
DWN SMD	DWG No. 915-C14-U855

REPORT No. H1720


Concrete gravity dam
Auxiliary spillway
Concrete gravity dam
Rockfill dam
Co
El 803.0
Ram
Road
Approx. ground surface at axis of dam
Penstocks
Drain tunnel,
Drain holes,
Till (removed)
Sand and gravel (removed in area of core)
Assumed rock surface at dam axis

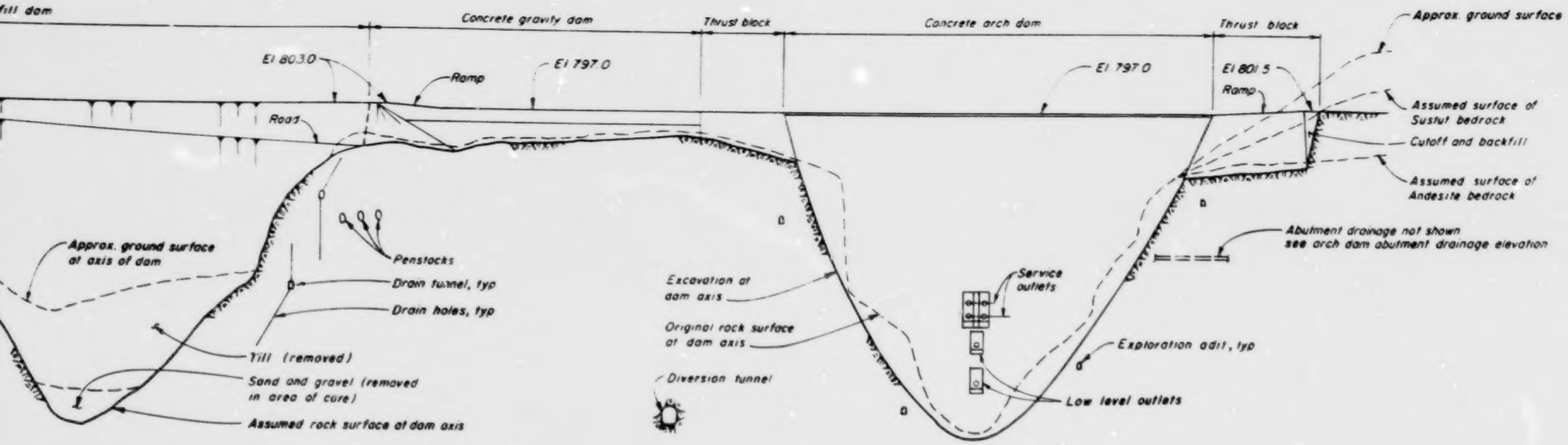
DEVELOPED DOW

S


Max normal reservoir level El 794.0
Min reservoir level El 749.0
El 797.0
10.0
El 803.0
El 792.0
1.4
1.4
1
1
El 753.0
1.75
1
0.12
1
0.12
El 700.0
2
1
Rockfill (Max size 1.2m)
Transition
0.5
1
0.2
1
Filter
Transition
0.5
1
Rockfill (Max size 1.2m)
1.75
1
6.0
15.0 Typ
Till (removed)
Impervious core
Rockfill (Max size 0.6m)
1
1.5
1
1.5
Sand/gravel from trench excavation
Existing sand and gravel
Blanket grouting as required
Grout curtain
Backfill concrete or shotcrete as required

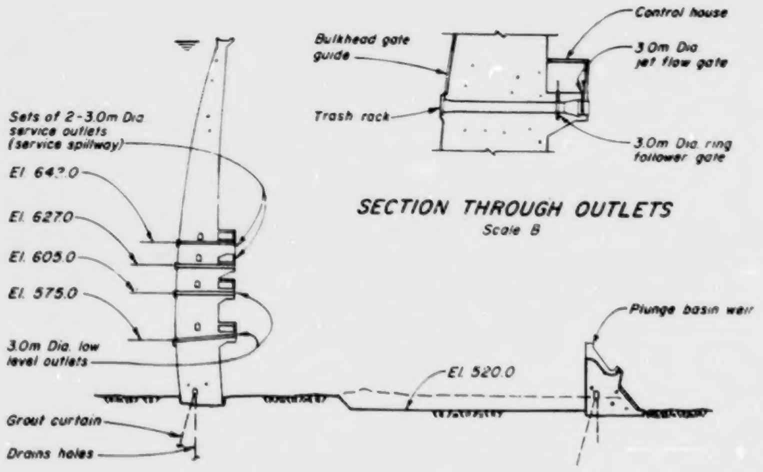
MAXIMUM SECTION THROUGH ROCKFILL DAM

Scale A


fill dam
Concrete gravity dam
Thrust block
Concrete arch dam
Thrust block
Approx. ground surface
El 803.0
El 797.0
Ramp
Road
El 797.0
El 801.5
Ramp
Assumed surface of Sustut bedrock
Cutoff and backfill
Assumed surface of Andesite bedrock
Abutment drainage not shown see arch dam abutment drainage elevation
Approx. ground surface at axis of dam
Penstocks
Drain tunnel, typ
Drain holes, typ
Excavation at dam axis
Original rock surface at dam axis
Service outlets
Exploration adit, typ
Till (removed)
Sand and gravel (removed in area of core)
Assumed rock surface at dam axis
Diversion tunnel
Low level outlets

DEVELOPED DOWNSTREAM ELEVATION

Scale A

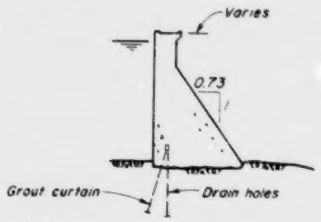

Bulkhead gate guide
Trash rack
Control house
3.0m Dia jet flow gate
3.0m Dia ring follower gate
Sets of 2-3.0m Dia service outlets (service spillway)
El. 642.0
El. 627.0
El. 605.0
El. 575.0
3.0m Dia. low level outlets
Grout curtain
Drains holes
Plunge basin weir
El. 520.0

SECTION THROUGH OUTLETS

Scale B

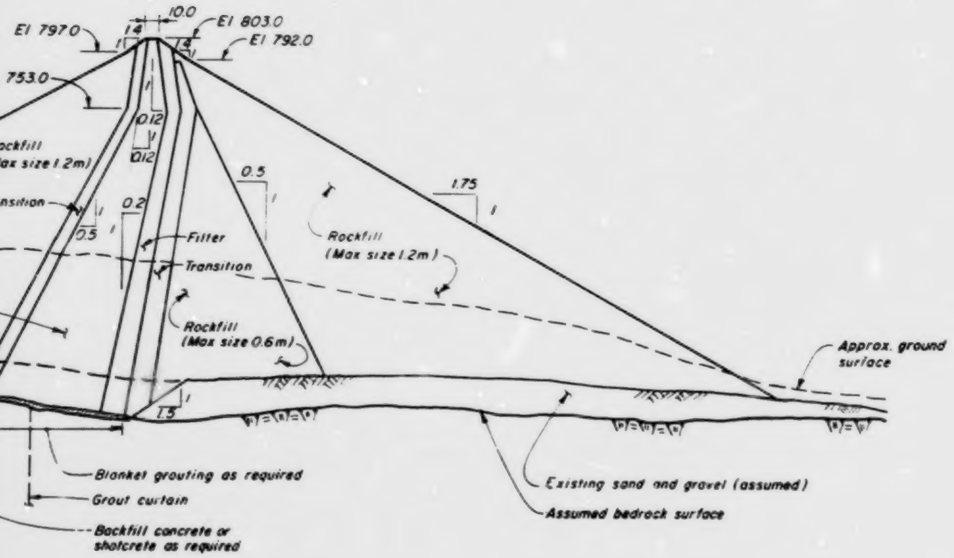
SECTION THROUGH CONCRETE ARCH DAM & PLUNGE BASIN

Scale A


Varies
0.73
1
Grout curtain
Drain holes

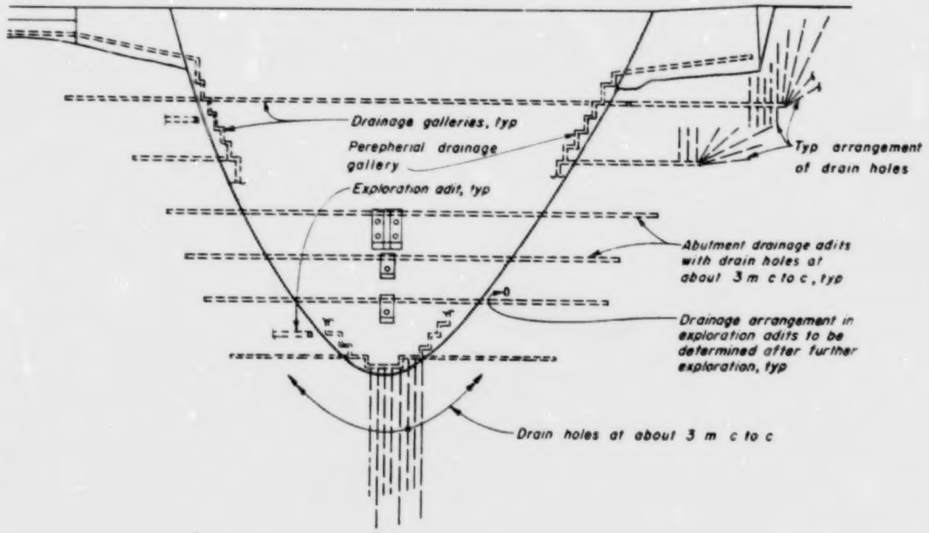
SECTION THROUGH CONCRETE GRAVITY DAM

Scale B


El 797.0
10.0
El 803.0
El 792.0
1.4
1
753.0
0.12
1
0.12
ockfill
ax size 1.2m)
nsition
0.5
1
0.2
1
0.5
1
Filter
Transition
Rockfill (Max size 1.2m)
1.75
1
Rockfill (Max size 0.6m)
1
1.5
Approx. ground surface
Blanket grouting as required
Grout curtain
Backfill concrete or shotcrete as required
Existing sand and gravel (assumed)
Assumed bedrock surface

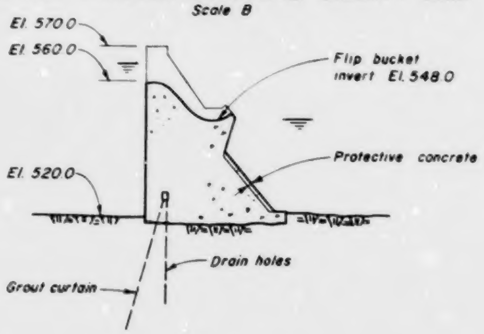
ECTION THROUGH ROCKFILL DAM

Scale A


Drainage galleries, typ
Perepherial drainage gallery
Exploration adit, typ
Typ arrangement of drain holes
Abutment drainage adits with drain holes at about 3 m c to c, typ
Drainage arrangement in exploration adits to be determined after further exploration, typ
Drain holes at about 3 m c to c

ARCH DAM ABUTMENT DRAINAGE DEVELOPED DOWNSTREAM ELEVATION

Scale A


El. 570.0
El. 560.0
Flip bucket invert El. 548.0
Protective concrete
El. 520.0
Grout curtain
Drain holes

PLUNGE BASIN WEIR

Scale B

Scale: B 20 0 20 40 60 80 Metres
Scale A 50 0 50 100 150 200 Metres

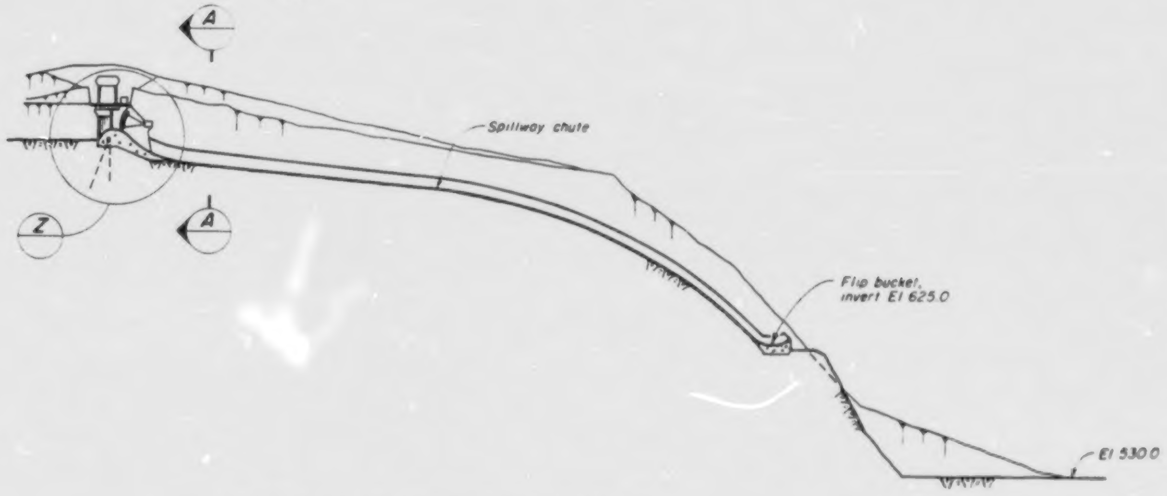
BRITISH COLUMBIA HYDRO AND POWER AUTHORITY

STIKINE-ISKUT DEVELOPMENT - STIKINE CANYON PROJECT

FEATURED ARRANGEMENT LAYOUT Z6
ELEVATIONS & SECTIONS

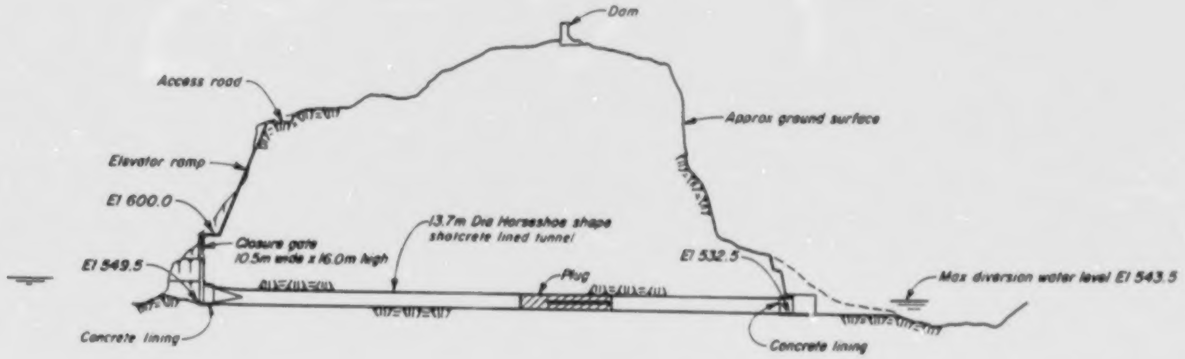
DATE DEC 1984	FIG. 3-4
DWN SMD	DWG No. 915-C14-U856

REPORT No. H1720


A
Spillway chute
Z
A
Flip bucket,
invert El 625.0
El 530.0

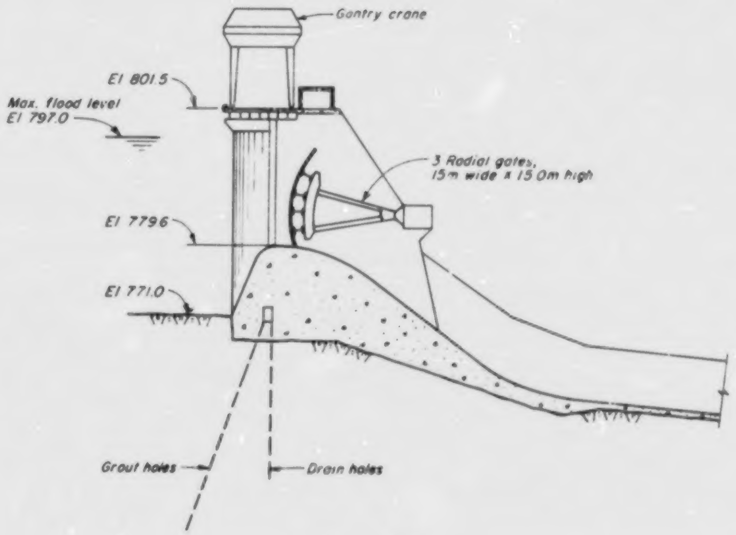
SECTION THROUGH AUXILIARY SPILLWAY

Scale A


Dam
Access road
Approx ground surface
Elevator ramp
El 600.0
Closure gate
10.5m wide x 16.0m high
13.7m Dia Horseshoe shape
shotcrete lined tunnel
El 549.5
Plug
El 532.5
Max diversion water level El 543.5
Concrete lining
Concrete lining

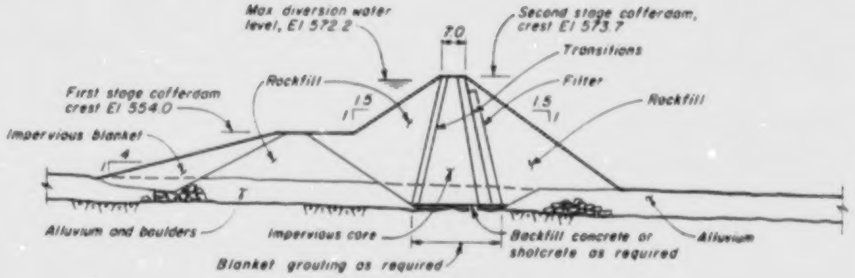
SECTION THROUGH DIVERSION TUNNEL

Scale A


Gantry crane
El 801.5
Max. flood level
El 797.0
3 Radial gates,
15m wide x 15.0m high
El 779.6
El 771.0
Grout holes
Drain holes

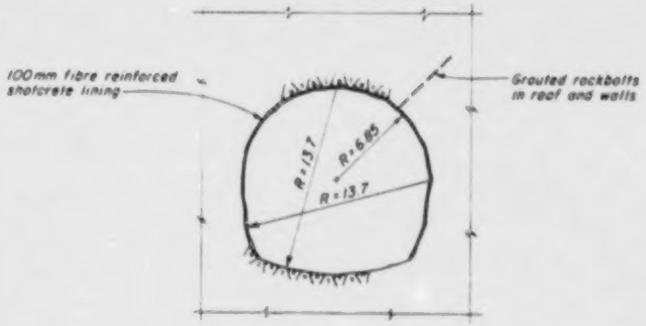
DETAIL Z

Scale B


Max diversion water
level, El 572.2
7.0
Second stage cofferdam,
crest El 573.7
Transitions
Rockfill
Filter
First stage cofferdam
crest El 554.0
1.5
1
1.5
1
Rockfill
Impervious blanket
4
1
Alluvium and boulders
Impervious core
Backfill concrete or
shotcrete as required
Alluvium
Blanket grouting as required

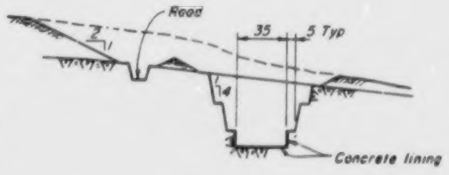
UPSTREAM COFFERDAM

Scale C


100mm fibre reinforced
shotcrete lining
Grouted rockbolts
in roof and walls
R=13.7
R=6.85
R=13.7

DIVERSION TUNNEL CROSS-SECTION

NTS


Road
2
1
35
5 Typ
14
Concrete lining

SECTION A

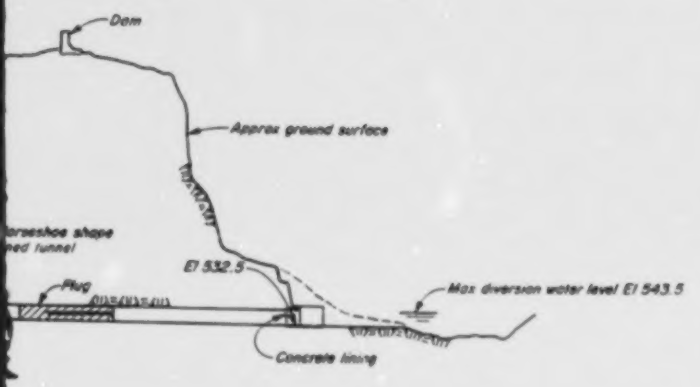
Scale A

STIKI
FEA
SEC

DATE D

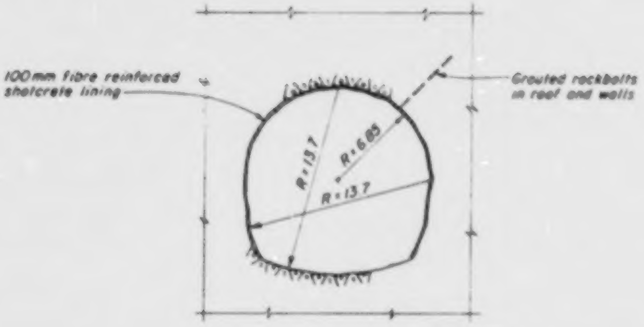
DWN S

REPORT


Dam
Approx ground surface
orseshoe shape
ned tunnel
El 532.5
Plug
Max diversion water level El 543.5
Concrete lining

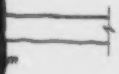
OUGH DIVERSION TUNNEL

Scale A


100mm fibre reinforced
shotcrete lining
Grouted rockbolts
in roof and walls
R=13.7
R=6.85
R=13.7

DIVERSION TUNNEL CROSS-SECTION

NTS



Scale: C 20 0 20 40 60 80 Metres
Scale: B 10 0 10 20 30 40 Metres
Scale: A 50 0 50 100 150 200 Metres

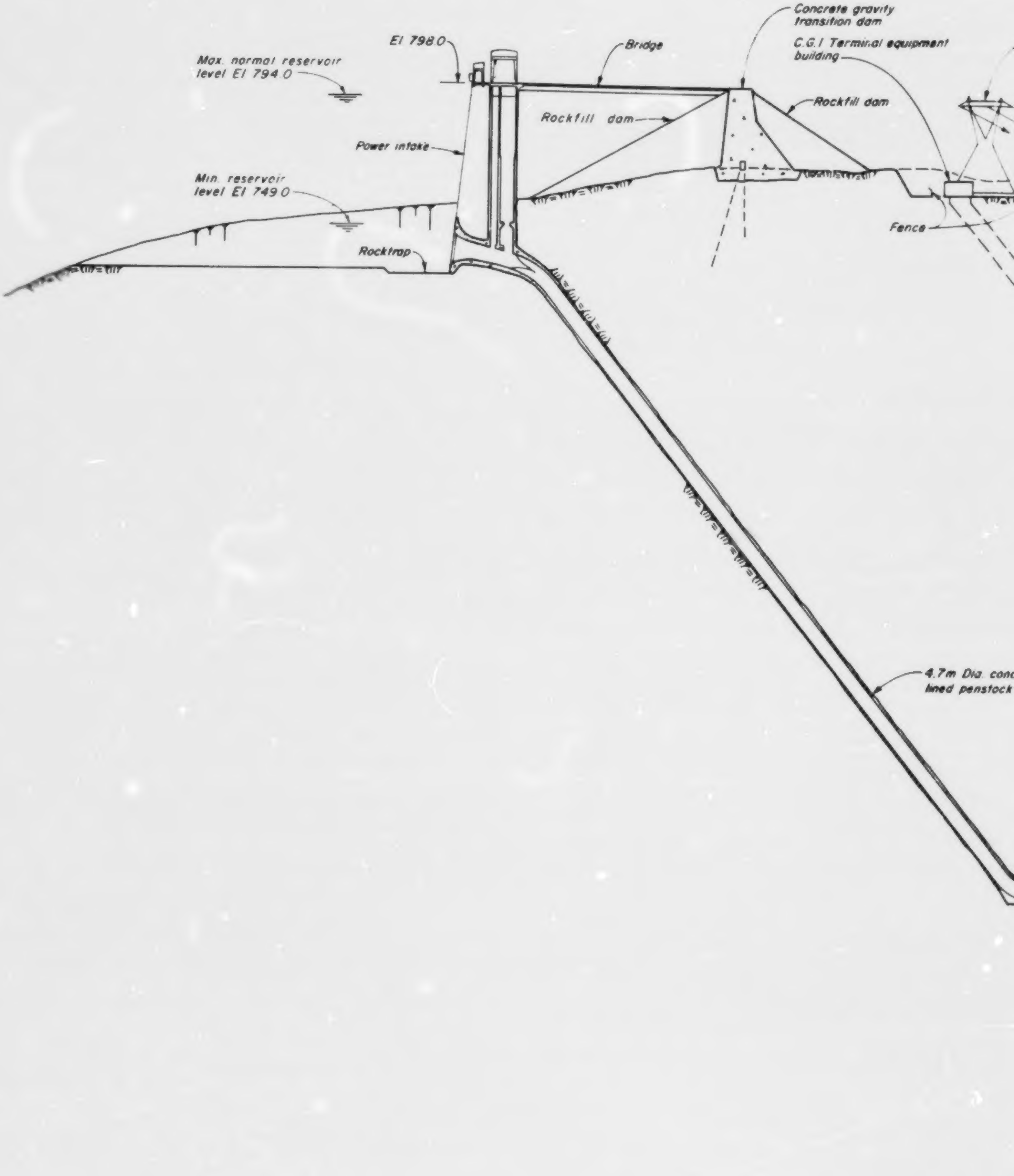
BRITISH COLUMBIA HYDRO AND POWER AUTHORITY

STIKINE-ISKUT DEVELOPMENT- STIKINE CANYON PROJECT

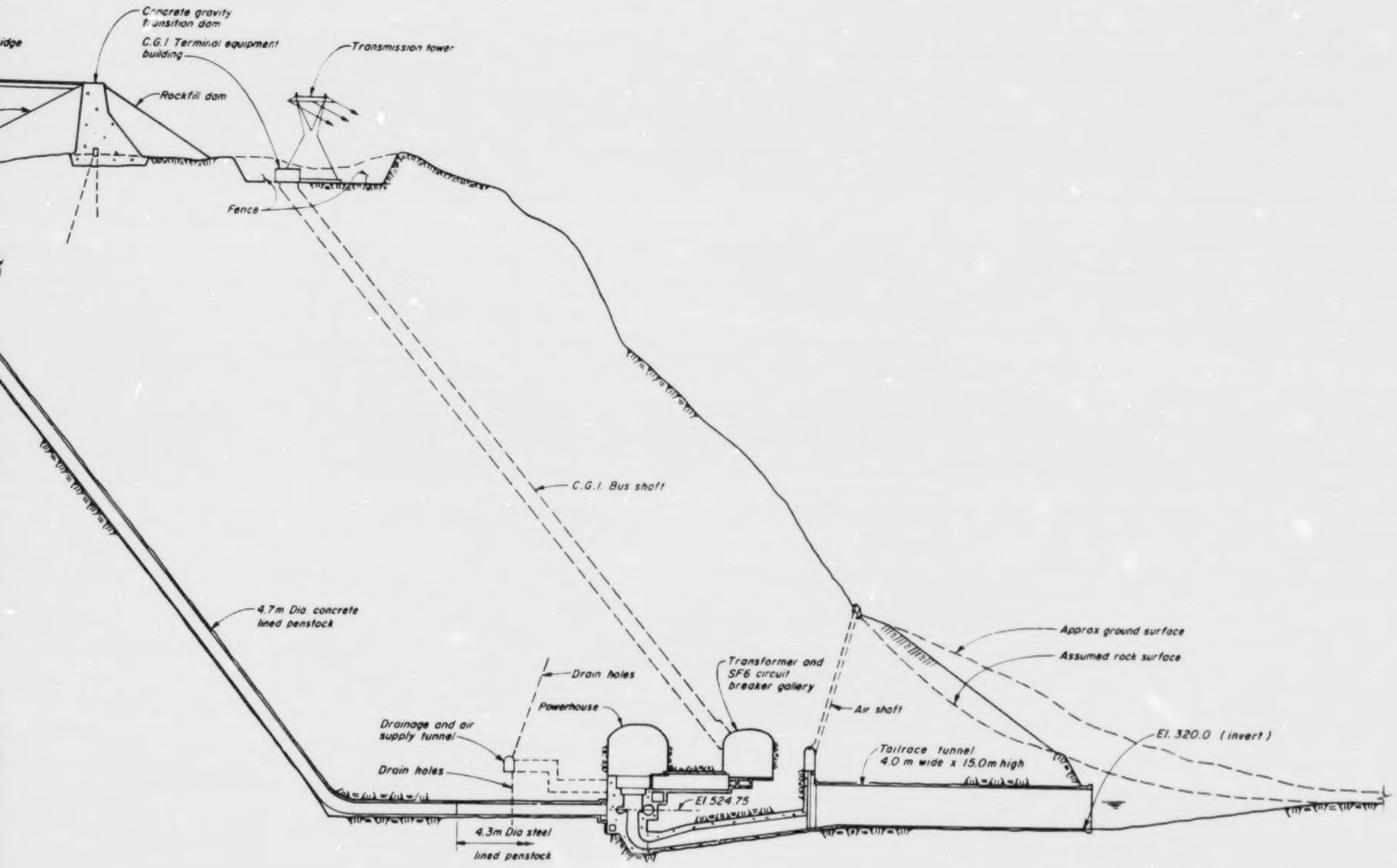
FEATURED ARRANGEMENT LAYOUT Z6
SECTIONS

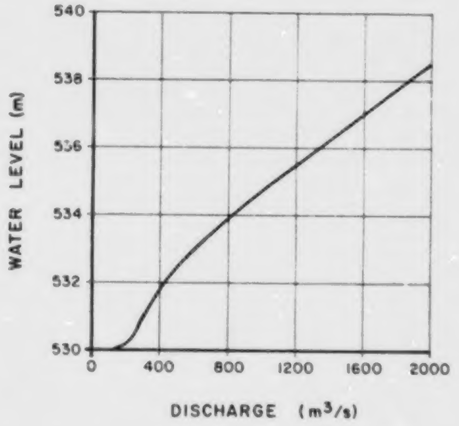
DATE DEC 1984	FIG. 3-5
DWN SMD	DWG No. 915-C14-U857

REPORT No. H1720



El 798.0
Max. normal reservoir level El 794.0
Bridge
Concrete gravity transition dam
C.G.I Terminal equipment building
Rockfill dam
Rockfill dam
Power intake
Min. reservoir level El 749.0
Rocktrap
Fence
4.7m Dia. conc
lined penstock


idge
Concrete gravity transition dam
C.G.I Terminal equipment building
Transmission tower
Rockfill dam
Fence
C.G.I. Bus shaft
4.7m Dia. concrete lined penstock
Drain holes
Transformer and SF6 circuit breaker gallery
Powerhouse
Air shaft
Drainage and air supply tunnel
Drain holes
Approx ground surface
Assumed rock surface
El. 320.0 (invert)
Tailrace tunnel 4.0 m wide x 15.0m high
El. 524.75
4.3m Dia steel lined penstock



TAILWATER DISCHARGE RATING CURVE

Scale: 20 0 20 40 60 80 Metres

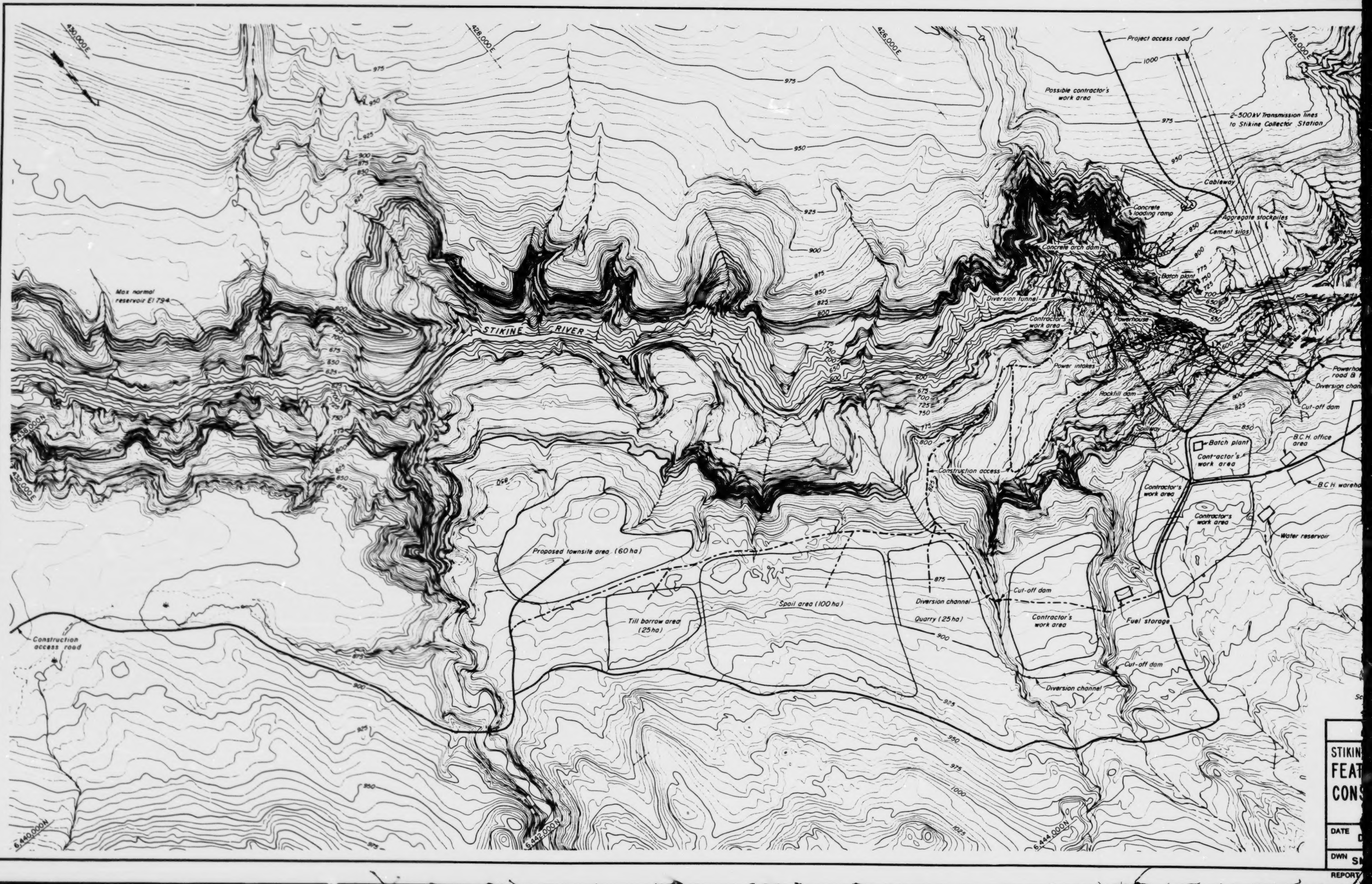
BRITISH COLUMBIA HYDRO AND POWER AUTHORITY

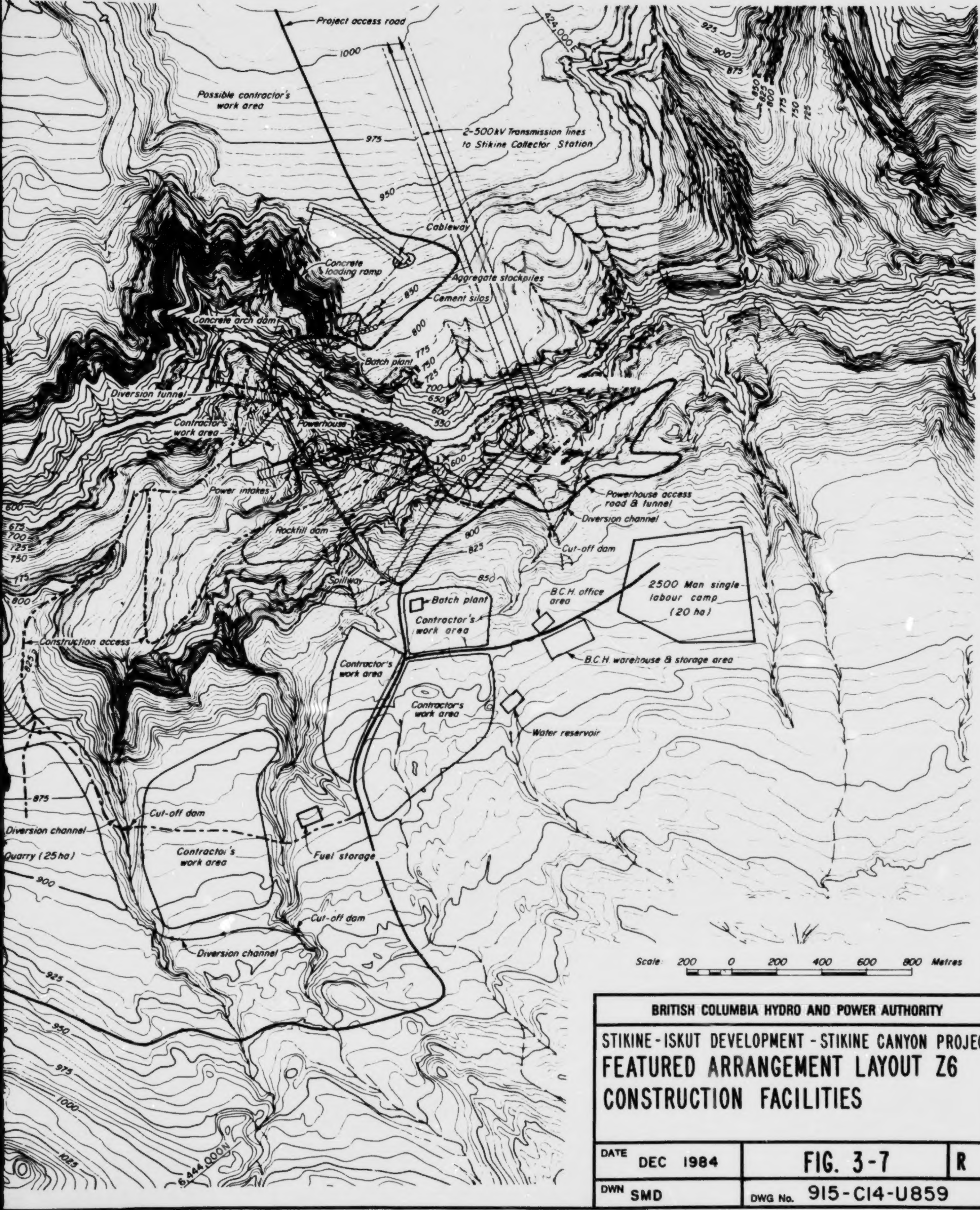
STIKINE-ISKUT DEVELOPMENT - STIKINE CANYON PROJECT

FEATURED ARRANGEMENT LAYOUT Z6
POWER FACILITIES
PROFILE

DATE DEC 1984	FIG. 3 - 6
DWN SMD	DWG No. 915-C14-U858

REPORT No. H1720


430,000E
428,000E
426,000E
424,000E
432,000E
6,438,000N
6,440,000N
6,442,000N
6,444,000N
975
950
925
900
875
850
825
800
775
750
725
700
675
650
625
600
550
1000
1025
Max normal reservoir El 794
STIKINE RIVER
Project access road
Possible contractor's work area
2-500kV Transmission lines to Stikine Collector Station
Cableway
Concrete loading ramp
Aggregate stockpiles
Cement silos
Concrete arch dam
Batch plant
Diversion tunnel
Contractor's work area
Powerhouse
Power intakes
Powerhou road &
Diversion chan
Rockfill dam
Cut-off dam
Spillway
Batch plant
Cont-actor's work area
B.C.H. office area
B.C.H. wareho
Contractor's work area
Contractor's work area
Water reservoir
Construction access
Proposed townsite area (60 ha)
Till borrow area (25ha)
Spoil area (100 ha)
Diversion channel
Quarry (25 ha)
Cut-off dam
Contractor's work area
Fuel storage
Cut-off dam
Diversion channel
Construction access road
Sc
STIKIN
FEAT
CONS
DATE
D
DWN
SM
REPORT


Project access road
1000
424,000 E
925
900
875
850
825
800
775
750
725
Possible contractor's work area
975
2-500 kV Transmission lines to Stikine Collector Station
950
Cableway
Concrete loading ramp
Aggregate stockpiles
850
Cement silos
Concrete arch dam
800
Batch plant
775
750
725
700
650
600
550
Diversion tunnel
Contractor's work area
Powerhouse
600
Power intakes
Powerhouse access road & tunnel
Diversion channel
600
675
700
725
750
Rockfill dam
800
825
Cut-off dam
775
800
Spillway
850
B.C.H. office area
2500 Man single labour camp (20 ha)
Batch plant
Contractor's work area
Construction access
825
Contractor's work area
B.C.H. warehouse & storage area
Contractor's work area
Water reservoir
875
Cut-off dam
Diversion channel
Quarry (25 ha)
Contractor's work area
Fuel storage
900
Cut-off dam
Diversion channel
925
950
975
1000
1025
6,444,000 N
Scale: 200 0 200 400 600 800 Metres

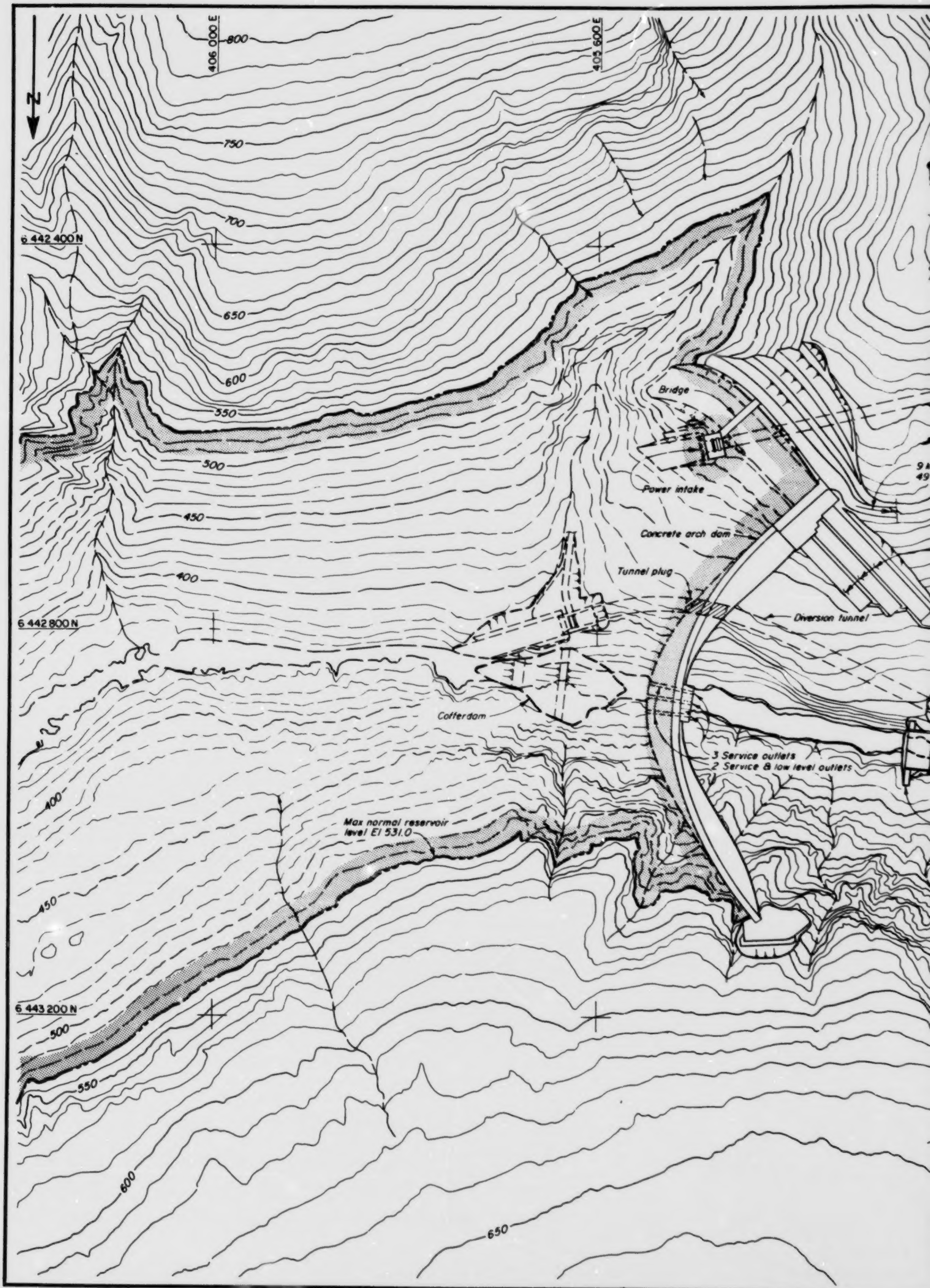
BRITISH COLUMBIA HYDRO AND POWER AUTHORITY

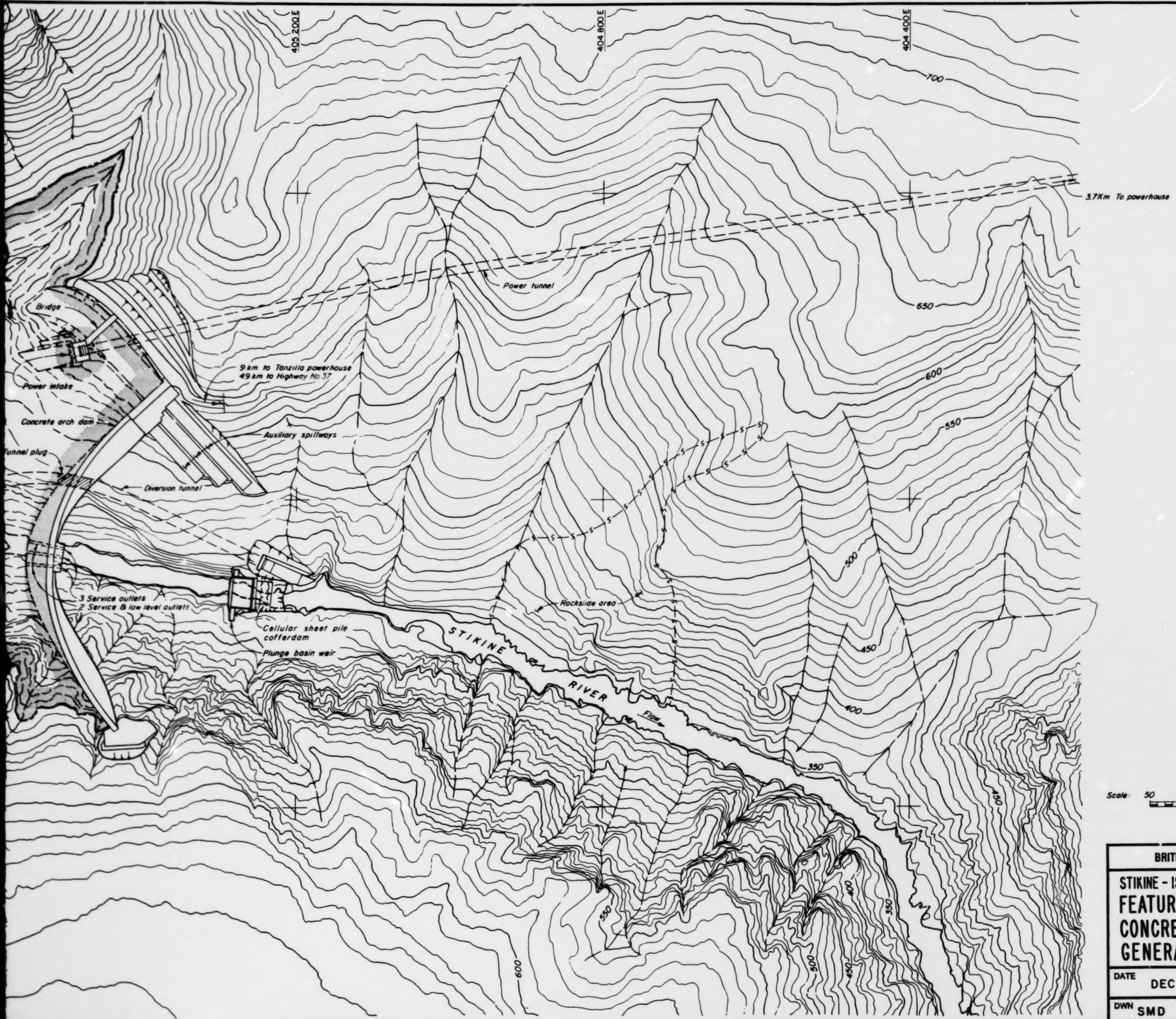
STIKINE - ISKUT DEVELOPMENT - STIKINE CANYON PROJECT

FEATURED ARRANGEMENT LAYOUT Z6
CONSTRUCTION FACILITIES

DATE DEC 1984	FIG. 3-7	R
DWN SMD	DWG No. 915-C14-U859	

REPORT No. H1720


N
406 000 E
405 600 E
800
750
700
650
600
550
500
450
400
6 442 400 N
6 442 800 N
6 443 200 N
Bridge
Power intake
Concrete arch dam
Tunnel plug
Diversion tunnel
Cofferdam
3 Service outlets
2 Service & low level outlets
Max normal reservoir level El 531.0
400
450
500
550
600
650


405 200 E
404 800 E
404 400 E
700
650
600
550
500
450
400
350
3.7Km To powerhouse
Power tunnel
Bridge
Power intake
Concrete arch dam
Tunnel plug
9 km to Tanzilla powerhouse
49 km to Highway No 37
Auxiliary spillways
Diversion tunnel
Rockslide area
3 Service outlets
2 Service & low level outlets
Cellular sheet pile cofferdam
Plunge basin weir
STIKINE RIVER
Flow
Scale: 50 0 50 100 150 200 Metres

BRITISH COLUMBIA HYDRO AND POWER AUTHORITY

STIKINE - ISKUT DEVELOPMENT - TANZILLA PROJECT

FEATURED ARRANGEMENT LAYOUT 1A
CONCRETE ARCH DAM
GENERAL PLAN

DATE DEC 1984

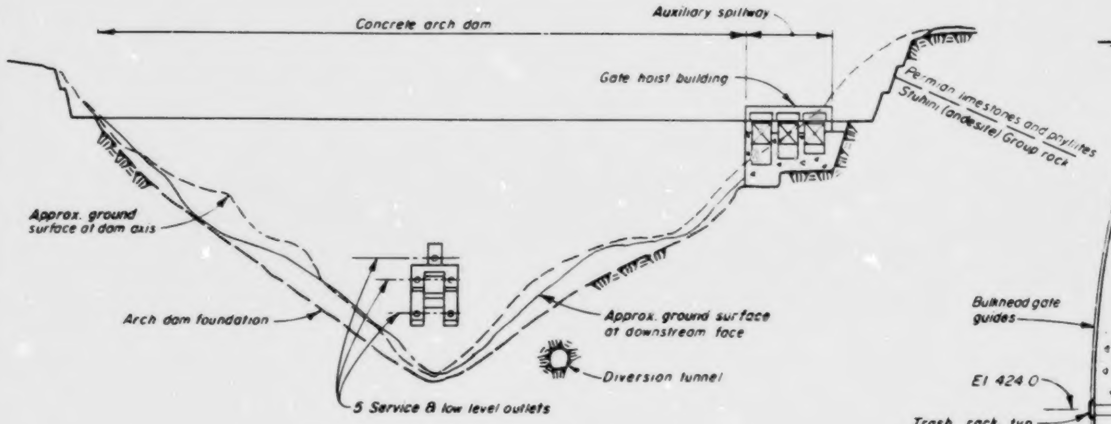
FIG. 3-8

R

DWN SMD

DWG No. 915 - C14 - U860

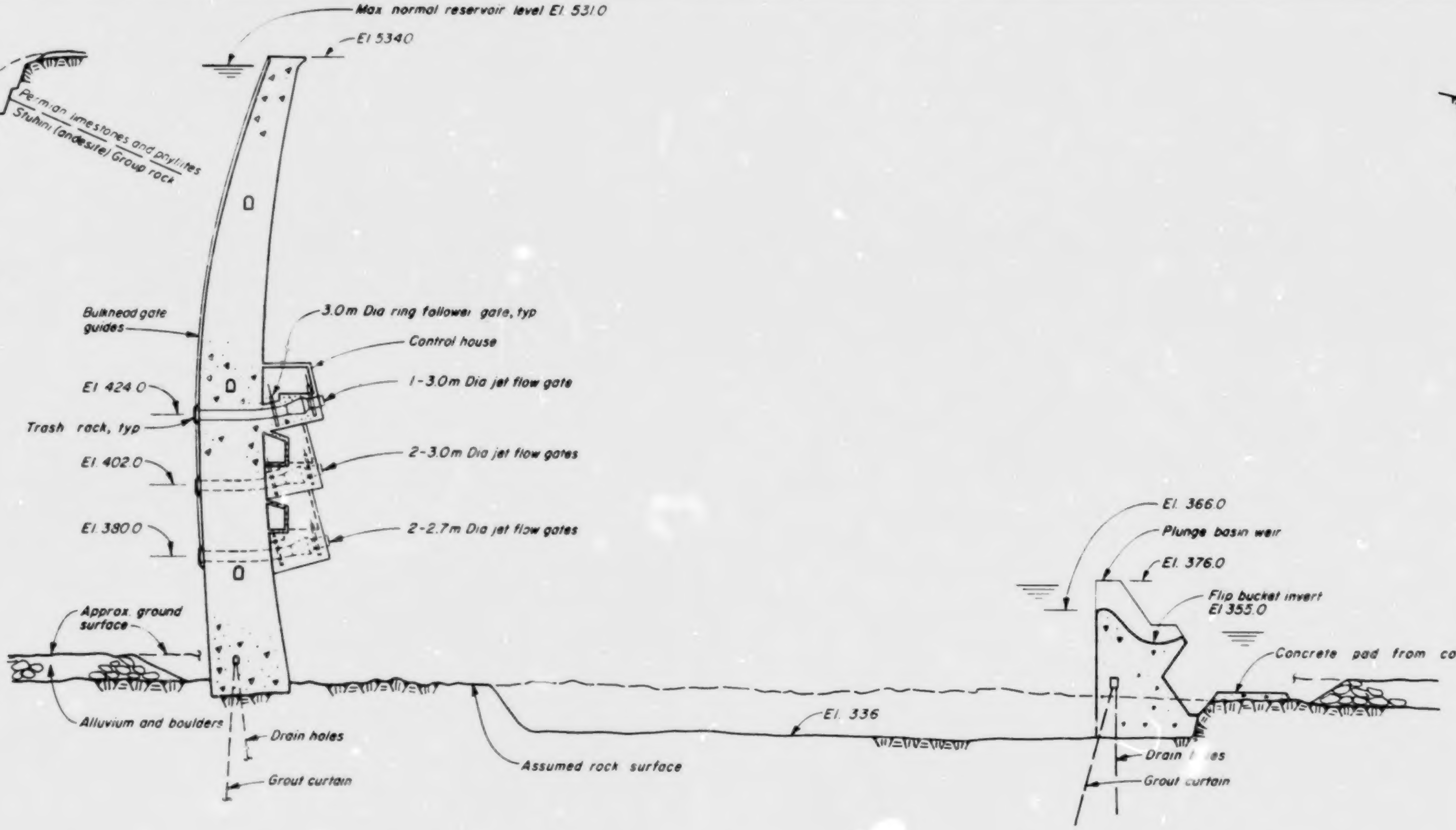
REPORT No. H1720



Concrete arch dam
Auxiliary spillway
Gate hoist building
Permian limestones and phyllites
Stuhini (andesite) Group rock
Approx. ground surface at dam axis
Arch dam foundation
Approx. ground surface at downstream face
Diversion tunnel
5 Service & low level outlets

DEVELOPED DOWNSTREAM ELEVATION

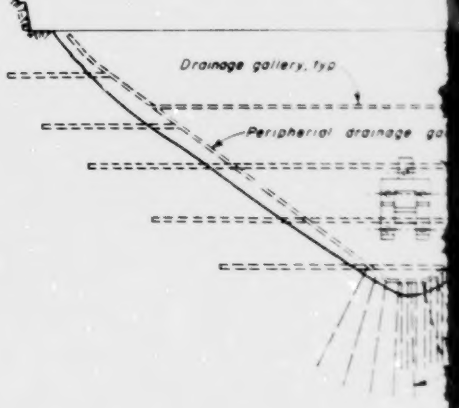
Scale A



Max normal reservoir level El 531.0
El 534.0
Bulkhead gate guides
3.0m Dia ring follower gate, typ
Control house
El 424.0
1-3.0m Dia jet flow gate
Trash rack, typ
El 402.0
2-3.0m Dia jet flow gates
El 380.0
2-2.7m Dia jet flow gates
Approx. ground surface
Alluvium and boulders
Drain holes
Grout curtain
Assumed rock surface
El. 336
El. 366.0
Plunge basin weir
El. 376.0
Flip bucket invert El 355.0
Concrete pad from cofferdam
Drain holes
Grout curtain

SECTION THROUGH CONCRETE ARCH DAM

Scale B

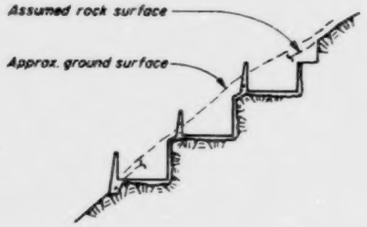


Drainage gallery, typ
Peripherial drainage ga

ARCH DAM ABU

DEVELOPED DOWN

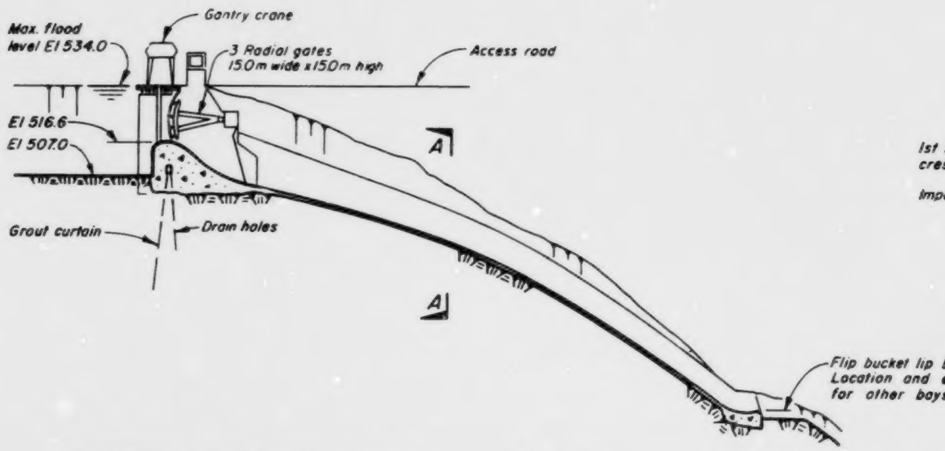
Sc



Assumed rock surface
Approx. ground surface

SECTION A-A

Scale B

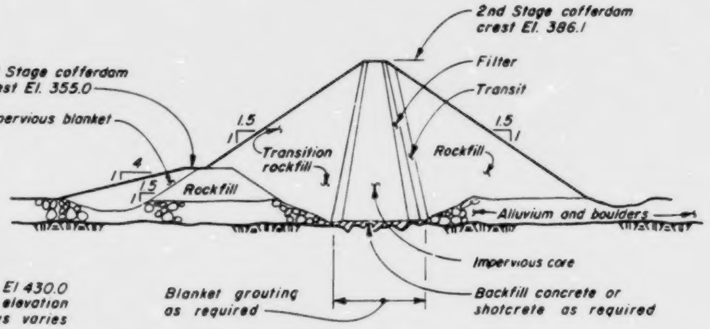


Max. flood level El 534.0
Gantry crane
3 Radial gates 15.0m wide x 15.0m high
Access road
El 516.6
El 507.0
A
Grout curtain
Drain holes
A
Flip bucket lip El 430.0 Location and elevation for other bays varies

SECTION THROUGH AUXILIARY SPILLWAY

Left bay shown

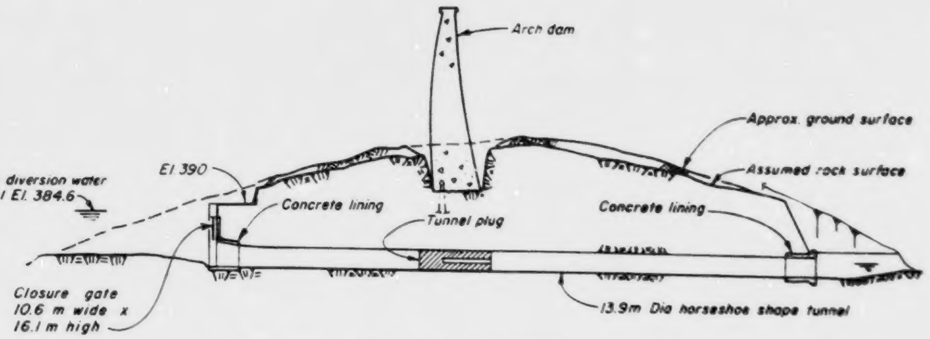
Scale B



2nd Stage cofferdam crest El. 386.1
1st Stage cofferdam crest El. 355.0
Filter
Transit
Impervious blanket
1.5
1
1.5
1
4
1
5
1
Transition rockfill
Rockfill
Rockfill
Alluvium and boulders
Impervious core
Blanket grouting as required
Backfill concrete or shotcrete as required

UPSTREAM COFFERDAM

Scale B



Arch dam
Approx. ground surface
Assumed rock surface
El 390
Max diversion water level El. 384.6
Concrete lining
Tunnel plug
Concrete lining
Closure gate 10.6 m wide x 16.1 m high
13.9m Dia horseshoe shape tunnel

SECTION THROUGH DIVERSION TUNNEL

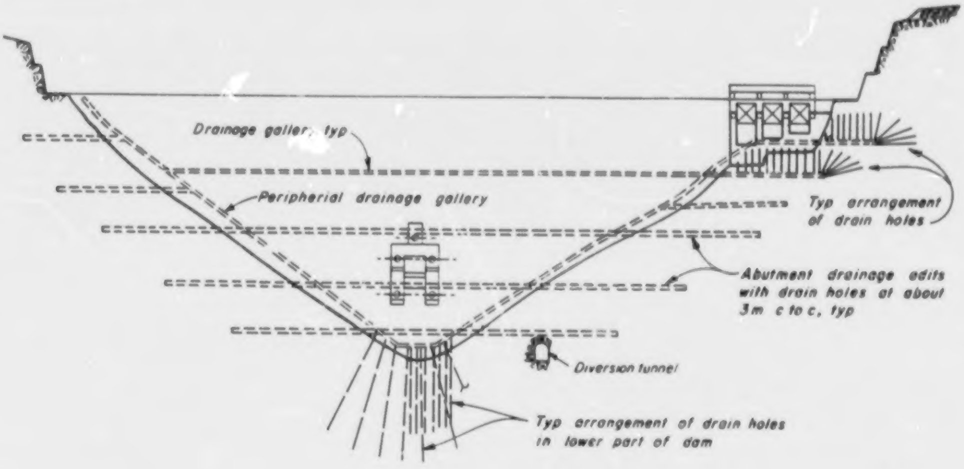
Scale A

STIKI
FEA
CON
EL

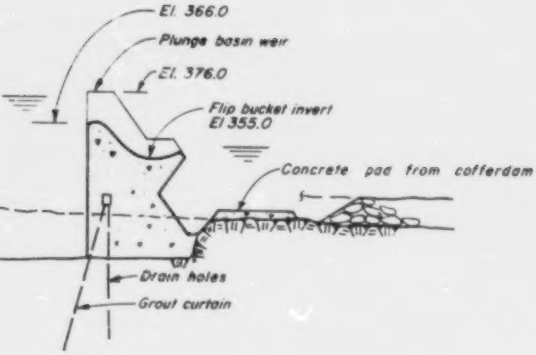
DATE

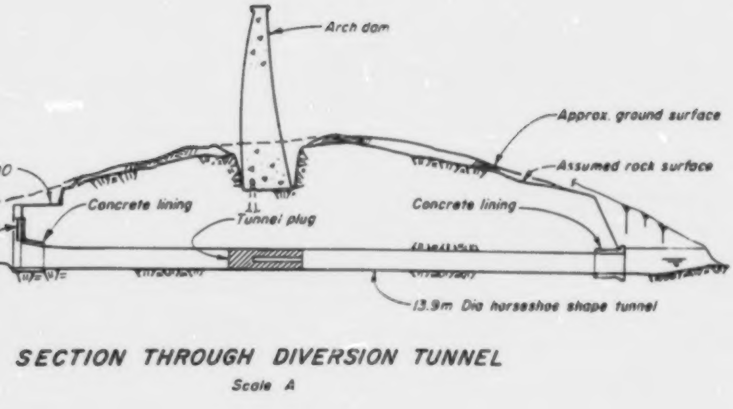
DWN S

REPORT


Drainage gallery, typ
Peripherial drainage gallery
Typ arrangement of drain holes
Abutment drainage adits with drain holes at about 3m c to c, typ
Diversion tunnel
Typ arrangement of drain holes in lower part of dam

ARCH DAM ABUTMENT DRAINAGE
DEVELOPED DOWNSTREAM ELEVATION
Scale A


El. 366.0
Plunge basin weir
El. 376.0
Flip bucket invert
El 355.0
Concrete pad from cofferdam
Drain holes
Grout curtain


Arch dam
Approx. ground surface
Assumed rock surface
00
Concrete lining
Tunnel plug
Concrete lining
13.9m Dia horseshoe shape tunnel

SECTION THROUGH DIVERSION TUNNEL
Scale A

Scale: B 20 0 20 40 60 80 Metres

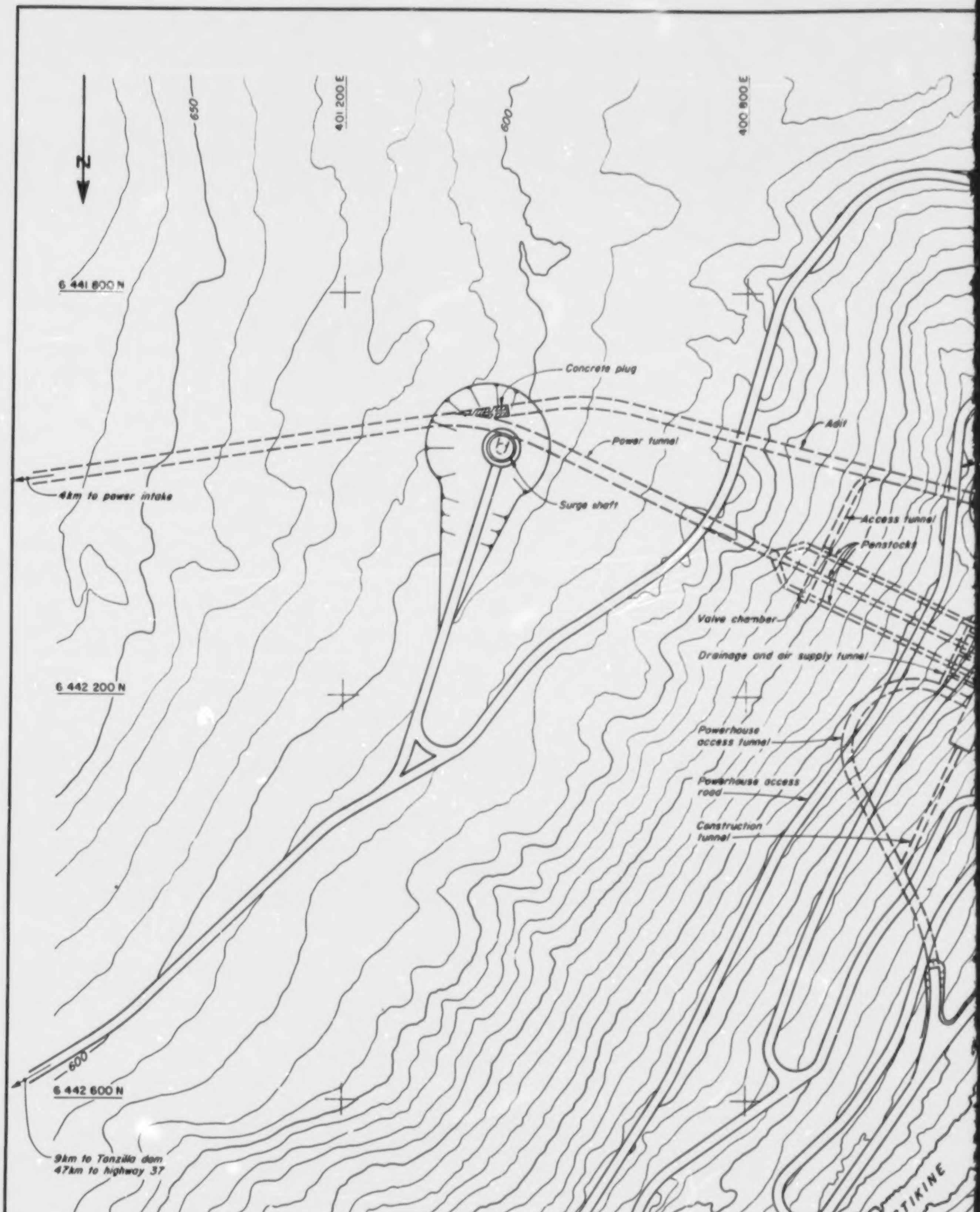
Scale: A 50 0 50 100 150 200 Metres

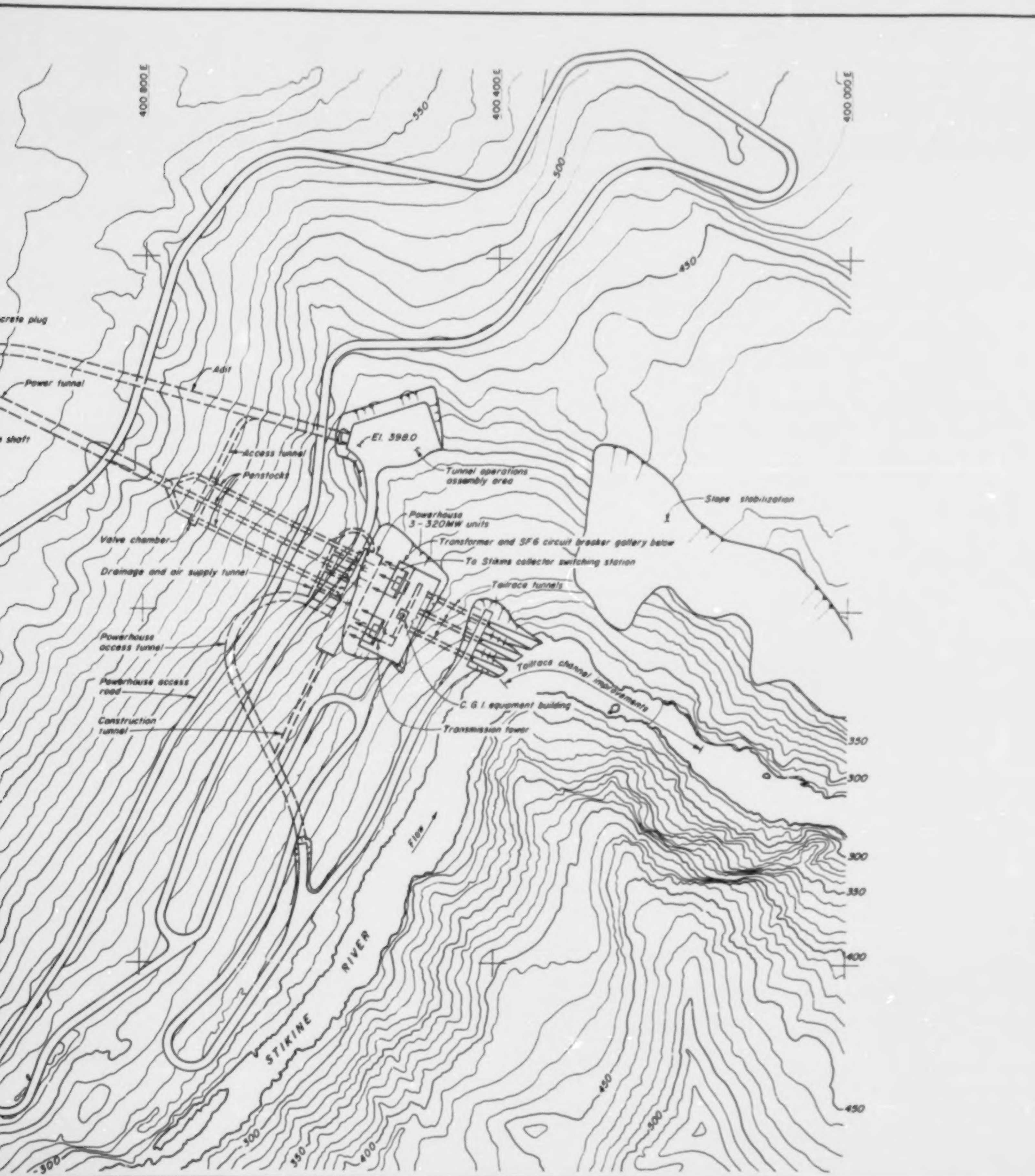
BRITISH COLUMBIA HYDRO AND POWER AUTHORITY

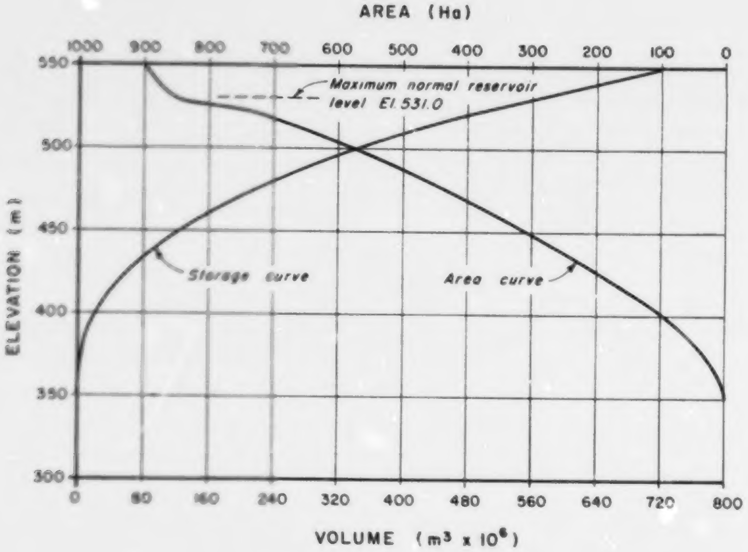
STIKINE-ISKUT DEVELOPMENT – TANZILLA PROJECT
FEATURED ARRANGEMENT LAYOUT IA
CONCRETE ARCH DAM
ELEVATIONS & SECTIONS

DATE DEC 1984	FIG. 3-9
DWN SMD	DWG No. 915-C14-U861

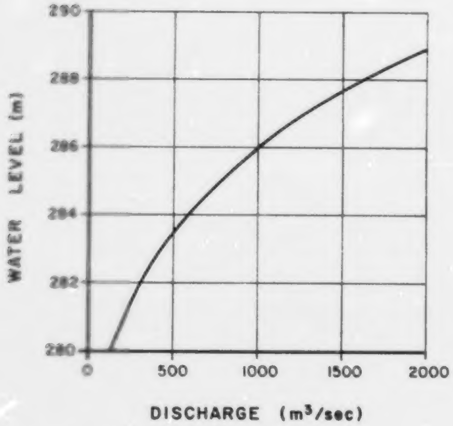
REPORT No. H1720


N
650
401 200 E
600
400 800 E
6 441 600 N
Concrete plug
Power tunnel
Adit
4km to power intake
Surge shaft
Access tunnel
Penstocks
Valve chamber
Drainage and air supply tunnel
6 442 200 N
Powerhouse access tunnel
Powerhouse access road
Construction tunnel
600
6 442 600 N
9km to Tanzilla dam
47km to highway 37
STIKINE
550
500
450
400
350
300
300
350


400 800 E
400 400 E
400 000 E
550
500
450
crete plug
Power tunnel
h shaft
Adit
Access tunnel
Penstocks
El. 398.0
Tunnel operations assembly area
Slope stabilization
Powerhouse 3 - 320MW units
Valve chamber
Transformer and SF6 circuit breaker gallery below
To Stikine collector switching station
Drainage and air supply tunnel
Tailrace tunnels
Powerhouse access tunnel
Tailrace channel improvements
Powerhouse access road
C. G. I. equipment building
Construction tunnel
Transmission tower
Flow
STIKINE RIVER
350
300
300
350
400
450
450
500
300
300
350
400



RESERVOIR - AREA, VOLUME



TAILWATER DISCHARGE RATING CURVE

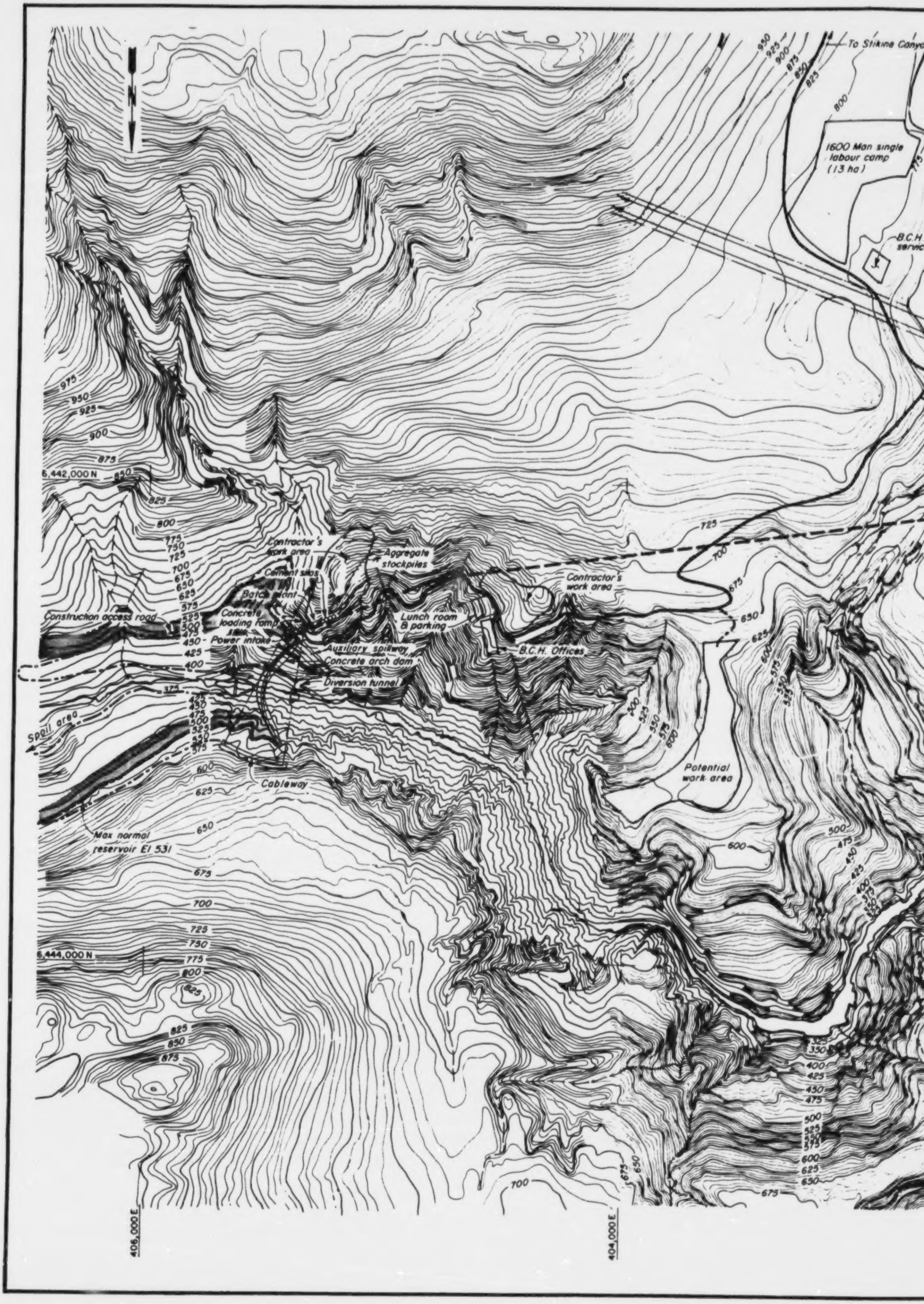
Scale: 50 0 50 100 150 200 Metres

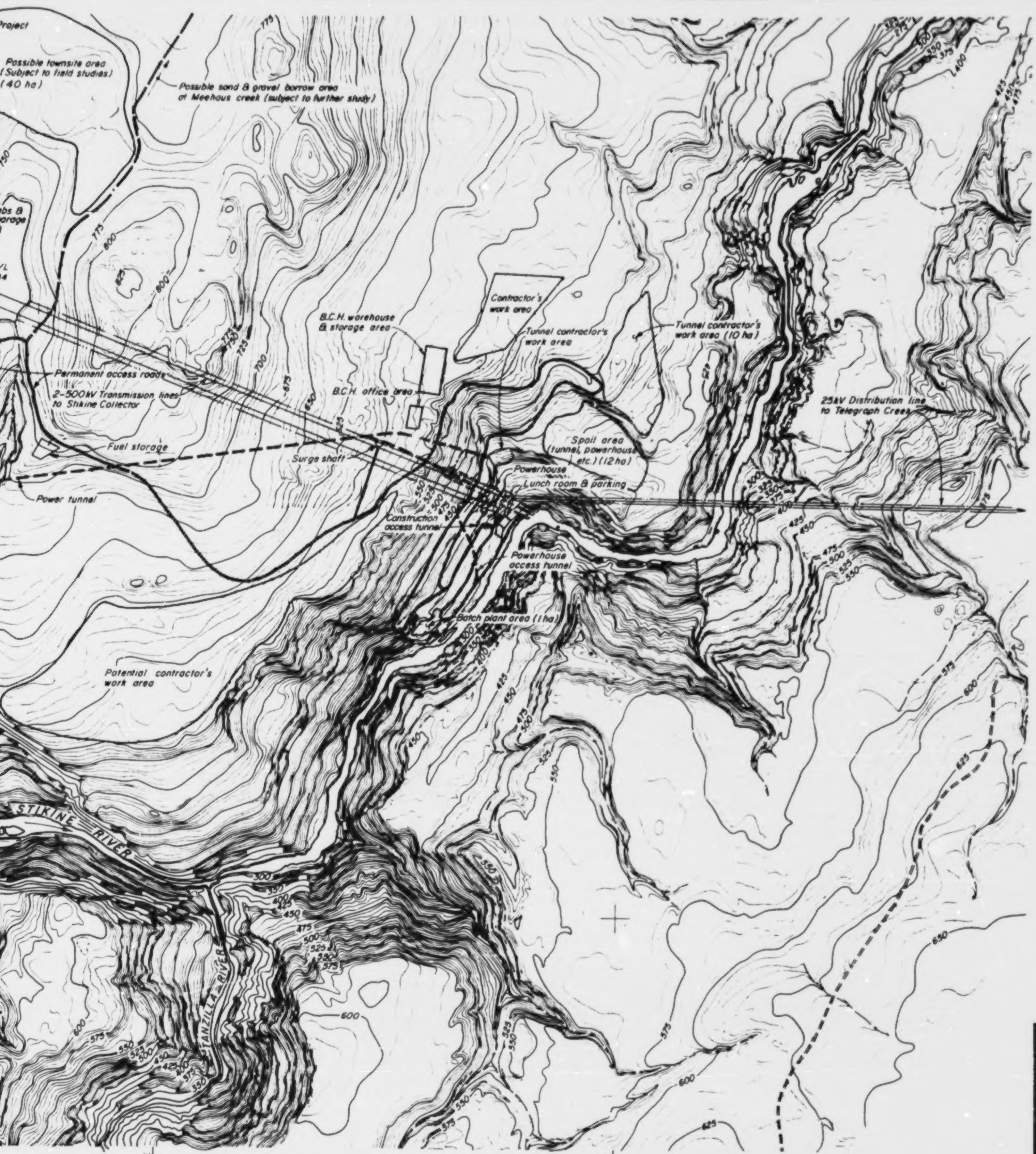
BRITISH COLUMBIA HYDRO AND POWER AUTHORITY

STIKINE-ISKUT DEVELOPMENT - TANZILLA PROJECT
FEATURED ARRANGEMENT LAYOUT IA
POWER FACILITIES
GENERAL PLAN

DATE DEC 1984	FIG. 3-10
DWN SMD	DWG No. 915-C14-U862

REPORT No. H1720


N
To Stikine Canyo
1600 Man single labour camp (13 ha)
B.C.H. servic
6,442,000 N
Contractor's work area
Aggregate stockpiles
Cement silos
Batch plant
Concrete loading ramp
Power intake
Construction access road
Lunch room & parking
Auxiliary spillway
Concrete arch dam
Diversion tunnel
B.C.H. Offices
Contractor's work area
Spoil area
Cableway
Potential work area
Max normal reservoir El 531
6,444,000 N
406,000 E
404,000 E

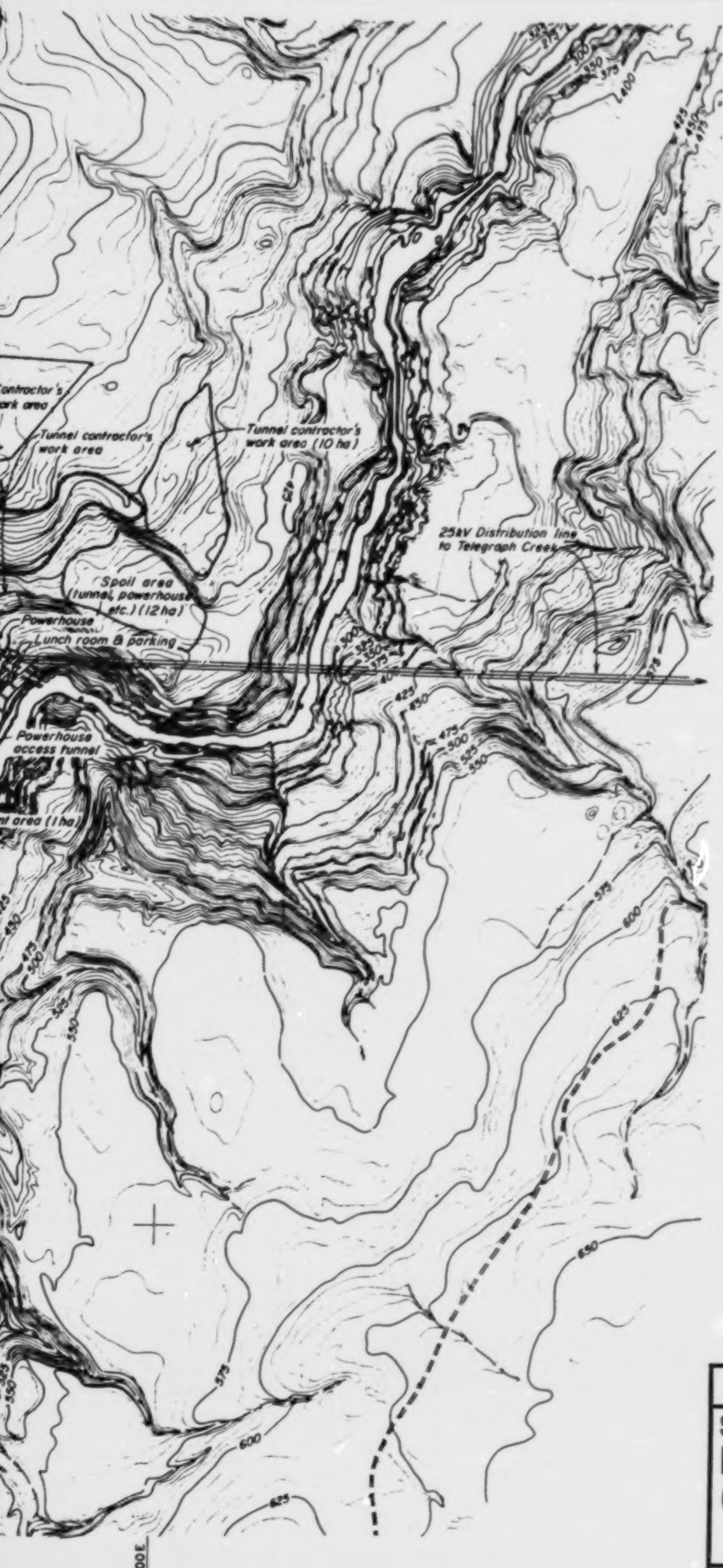

Project
Possible townsite area (Subject to field studies) (40 ha)
Possible sand & gravel borrow area at Meehous creek (subject to further study)
bs & orage
Contractor's work area
B.C.H. warehouse & storage area
Tunnel contractor's work area
Tunnel contractor's work area (10 ha)
Permanent access roads
2-500kV Transmission lines to Stikine Collector
B.C.H. office area
25kV Distribution line to Telegraph Creek
Fuel storage
Surge shaft
Spoil area (tunnel, powerhouse etc.) (12 ha)
Powerhouse
Lunch room & parking
Power tunnel
Construction access tunnel
Powerhouse access tunnel
Batch plant area (1 ha)
Potential contractor's work area
STIKINE RIVER
TANZILLA RIVER
402,000 E
400,000 E
775
800
825
750
700
675
650
625
600
575
550
525
500
475
450
425
400
375
350
325
300

STIKI
FEA
CON

DATE

DWN

REPOR


Contractor's work area
Tunnel contractor's work area
Tunnel contractor's work area (10 ha)
25kV Distribution line to Telegraph Creek
Spoil area (tunnel, powerhouse etc.) (12 ha)
Powerhouse
Lunch room & parking
Powerhouse access tunnel
nt area (1 ha)
400,000E

Scale: 200 0 200 400 600 800 Metres

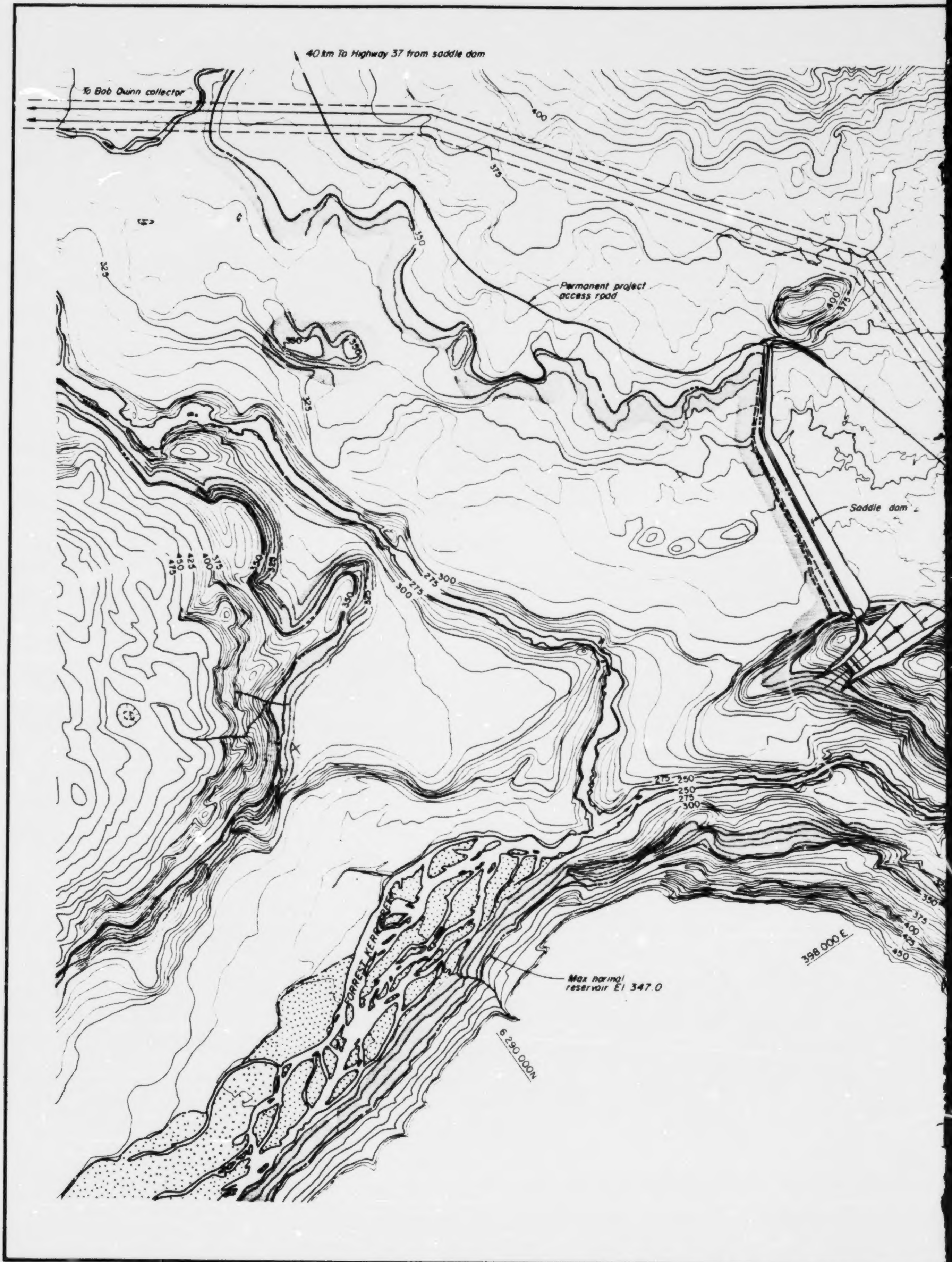
BRITISH COLUMBIA HYDRO AND POWER AUTHORITY

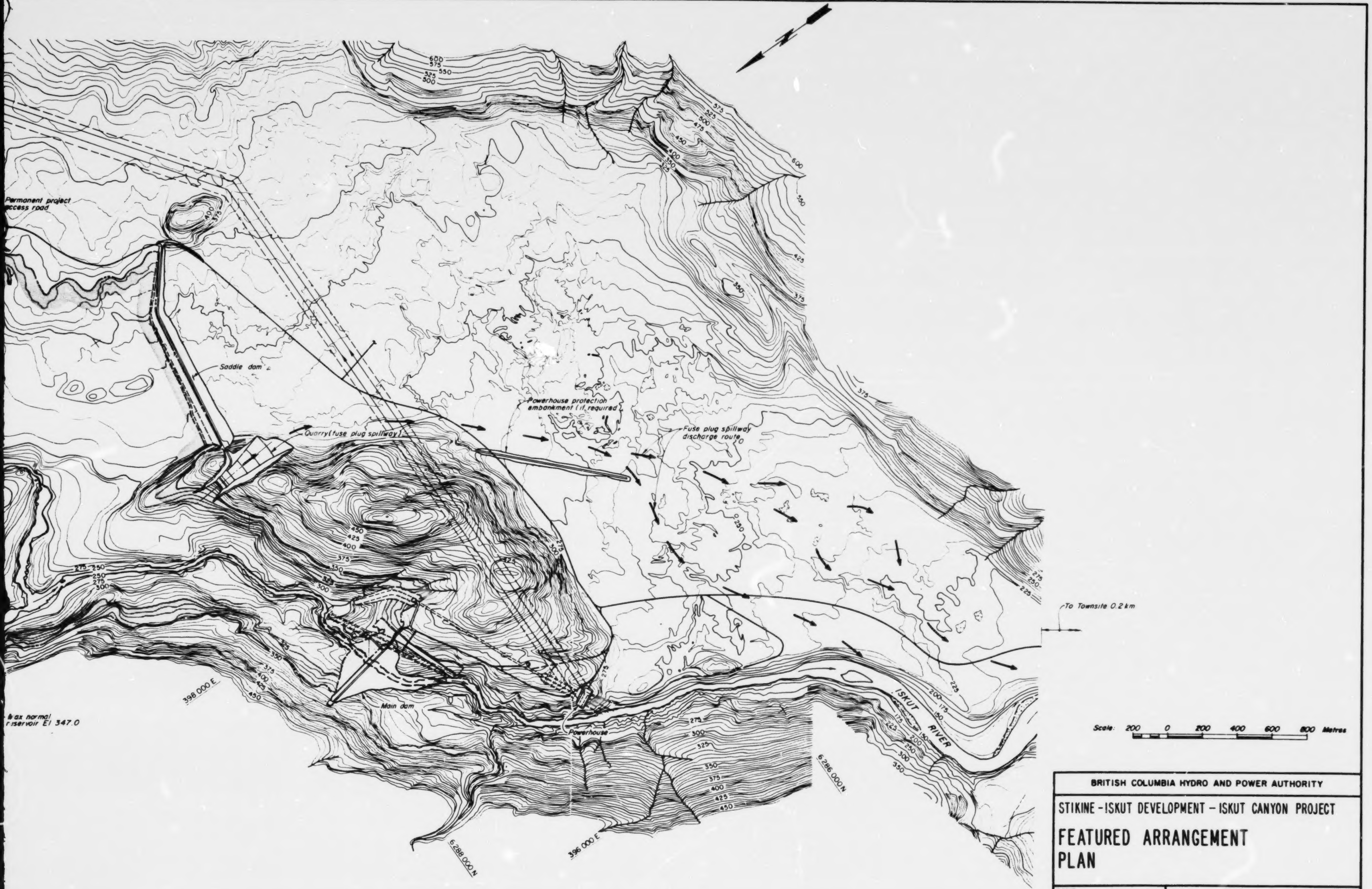
STIKINE - ISKUT DEVELOPMENT - TANZILLA PROJECT

FEATURED ARRANGEMENT LAYOUT 1A
CONSTRUCTION FACILITIES

DATE DEC 1984	FIG. 3-11	R
DWN SMD	DWG No. 915-C14-U863	

REPORT No. H1720


40 km To Highway 37 from saddle dam
To Bob Quinn collector
400
375
350
325
Permanent project access road
400
375
350
350
325
Saddle dam
475
450
425
400
375
350
325
350
325
300
275
275
300
275-250
250
275
300
350
375
400
425
450
398 000 E
FORREST KERR CREEK
Max normal reservoir El 347.0
6 290 000N


Permanent project access road
Saddle dam
Quarry (fuse plug spillway)
Powerhouse protection embankment (if required)
Fuse plug spillway discharge route
To Townsite 0.2 km
Max normal reservoir El 347.0
Main dam
Powerhouse
ISKUT RIVER
398 000 E
396 000 E
6 288 000 N
6 286 000 N
Scale: 200 0 200 400 600 800 Metres

BRITISH COLUMBIA HYDRO AND POWER AUTHORITY

STIKINE - ISKUT DEVELOPMENT - ISKUT CANYON PROJECT

FEATURED ARRANGEMENT PLAN

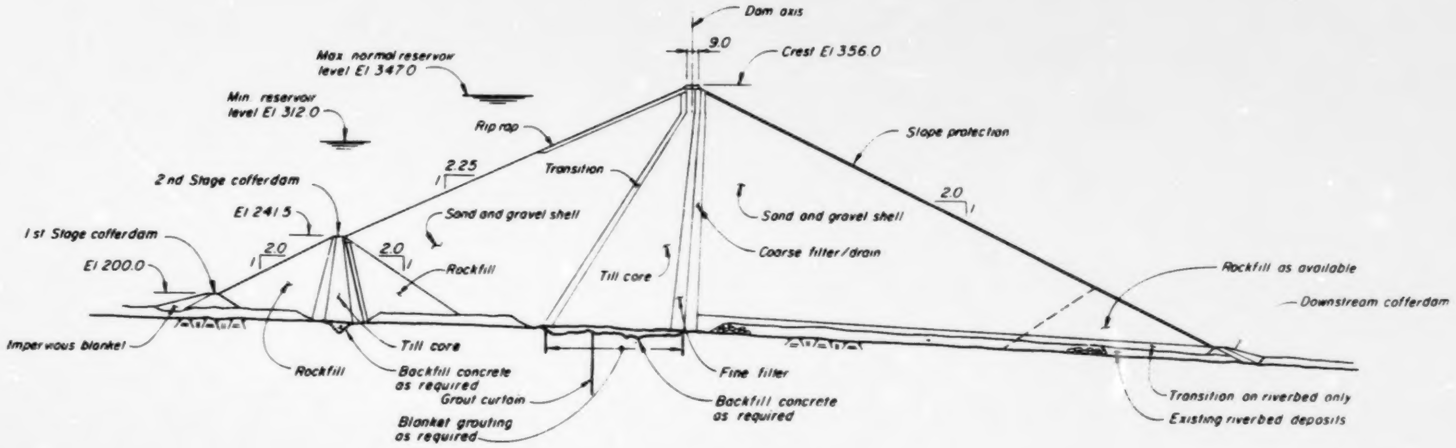
DATE DEC 1984

FIG. 3-12

DWN PSK

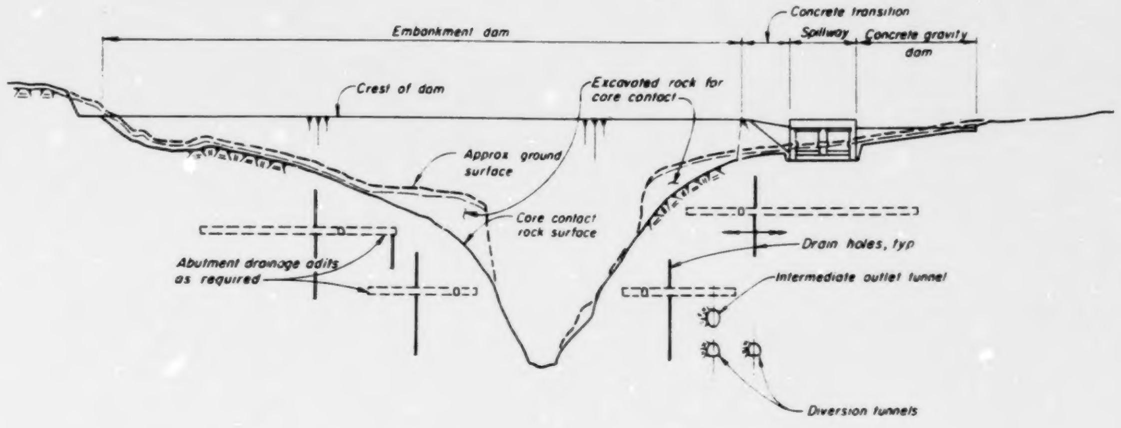
DWG No 913-C14-C471

REPORT No H1720


Dam axis
9.0
Crest El 356.0
Max normal reservoir level El 347.0
Min. reservoir level El 312.0
Rip rap
Slope protection
2.25
1
Transition
2nd Stage cofferdam
El 241.5
Sand and gravel shell
Sand and gravel shell
2.0
1
1st Stage cofferdam
2.0
1
2.0
1
El 200.0
Rockfill
Coarse filter/drain
Till core
Rockfill as available
Downstream cofferdam
Impervious blanket
Till core
Rockfill
Backfill concrete as required
Grout curtain
Blanket grouting as required
Fine filter
Backfill concrete as required
Transition on riverbed only
Existing riverbed deposits

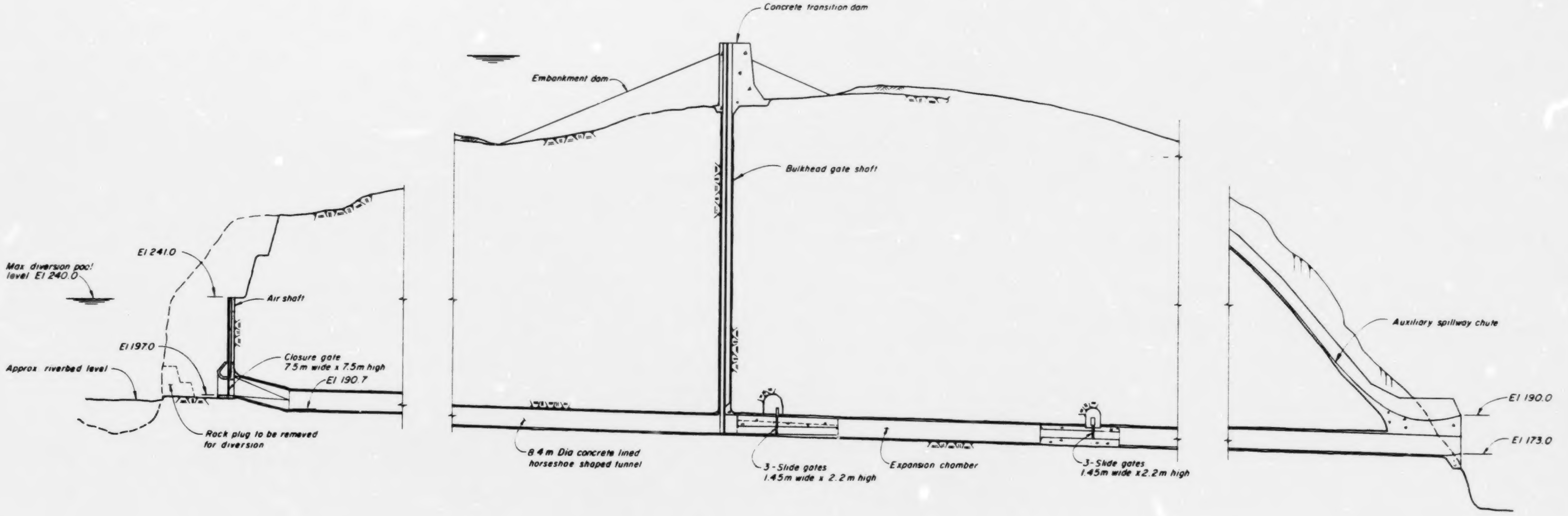
SECTION THROUGH EMBANKMENT DAM

Scale: A


Concrete transition
Embankment dam
Spillway
Concrete gravity dam
Crest of dam
Excavated rock for core contact
Approx ground surface
Core contact rock surface
Abutment drainage adits as required
Drain holes, typ
Intermediate outlet tunnel
Diversion tunnels

DEVELOPED SECTION ALONG DAM AXIS

Scale A


Concrete transition dam
Embankment dam
Bulkhead gate shaft
El 241.0
Max diversion pool level El 240.0
Air shaft
El 197.0
Closure gate 7.5m wide x 7.5m high
El 190.7
Approx riverbed level
Rock plug to be removed for diversion
8.4m Dia concrete lined horseshoe shaped tunnel
3-Slide gates 1.45m wide x 2.2m high
Expansion chamber
3-Slide gates 1.45m wide x 2.2m high
Auxiliary spillway chute
El 190.0
El 173.0

SECTION THROUGH DIVERSION TUNNEL AND LOW LEVEL OUTLET

Scale B

Scale:

Scale

All di

ST

FE

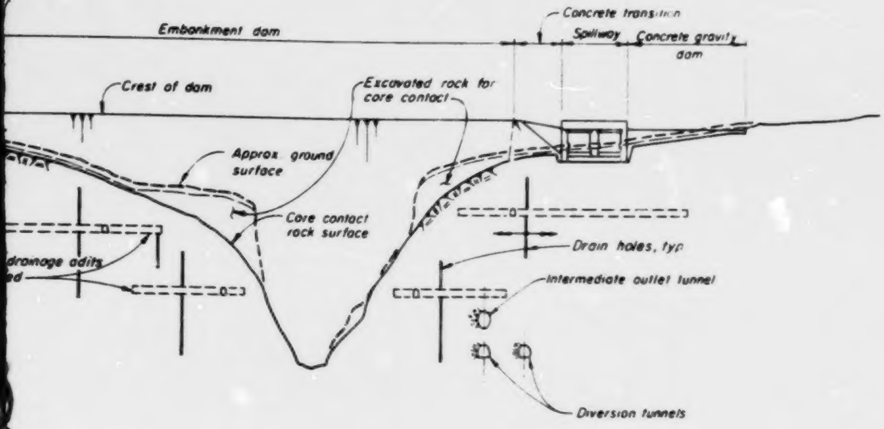
LA

SE

DATE

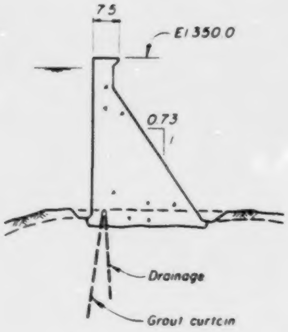
DWN

REPOR


Embankment dam
Concrete transition
Spillway
Concrete gravity dam
Crest of dam
Excavated rock for core contact
Approx. ground surface
Core contact rock surface
Drain holes, typ
drainage adits
ad
Intermediate outlet tunnel
Diversion tunnels

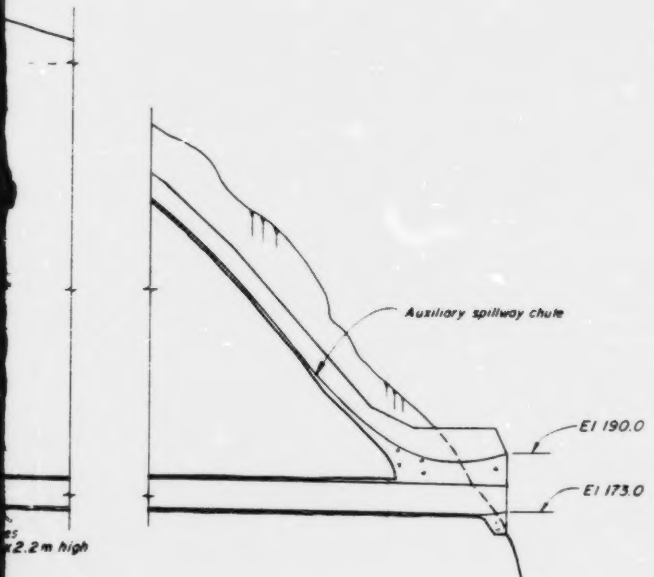
DEVELOPED SECTION ALONG DAM AXIS

Scale A


7.5
El 350.0
0.73
1
Drainage
Grout curtain

SECTION THROUGH
CONCRETE GRAVITY DAM

Scale B


Auxiliary spillway chute
El 190.0
El 173.0
es
x2.2 m high

Scale: B 20 0 20 40 60 80 Metres
Scale A 50 0 50 100 150 200 Metres

All dimensions are in metres, unless otherwise shown

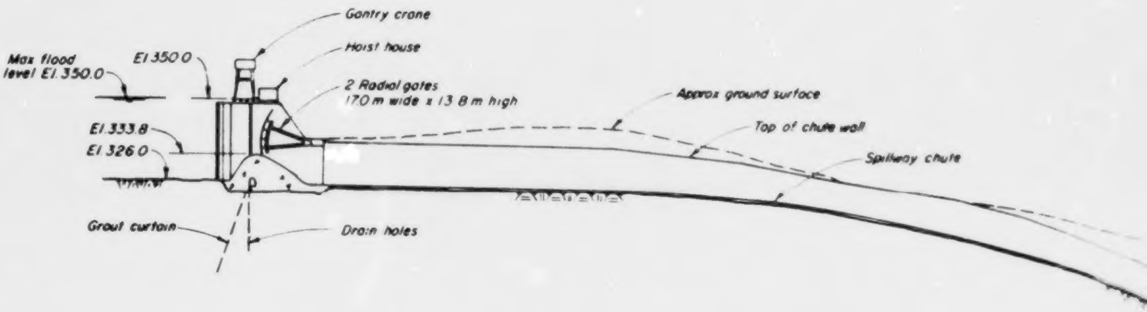
BRITISH COLUMBIA HYDRO AND POWER AUTHORITY

STIKINE - ISKUT DEVELOPMENT - ISKUT CANYON PROJECT

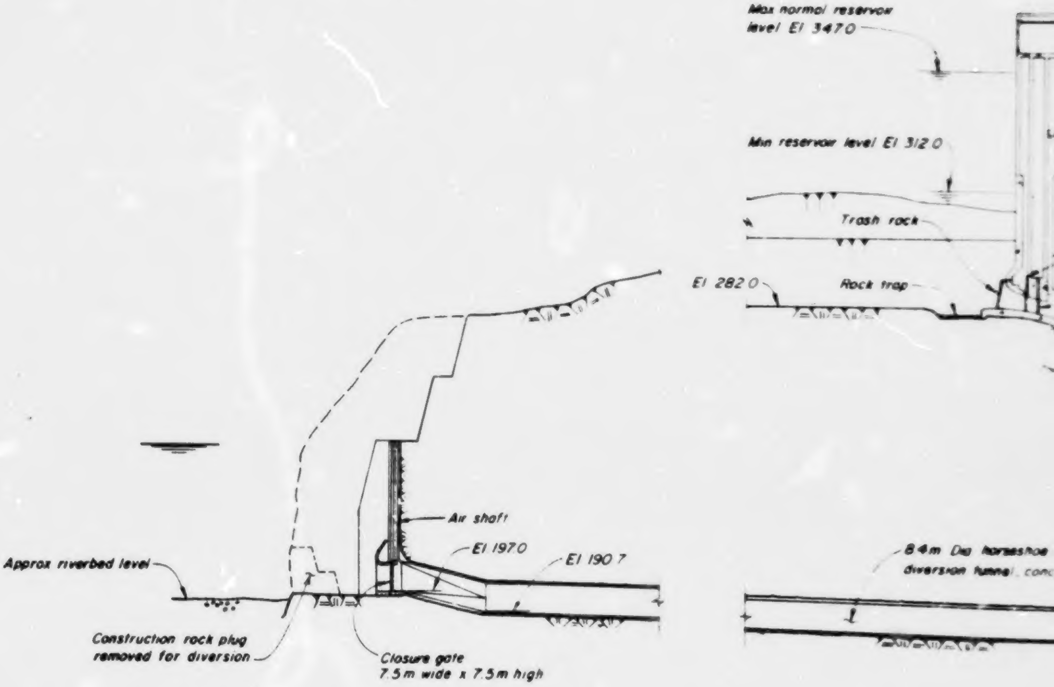
FEATURED ARRANGEMENT LAYOUT WITH CORE EMBANKMENT DAM SECTIONS

DATE DEC 1984	FIG. 3-13
DWN CY	DWG No 913-C14-C472

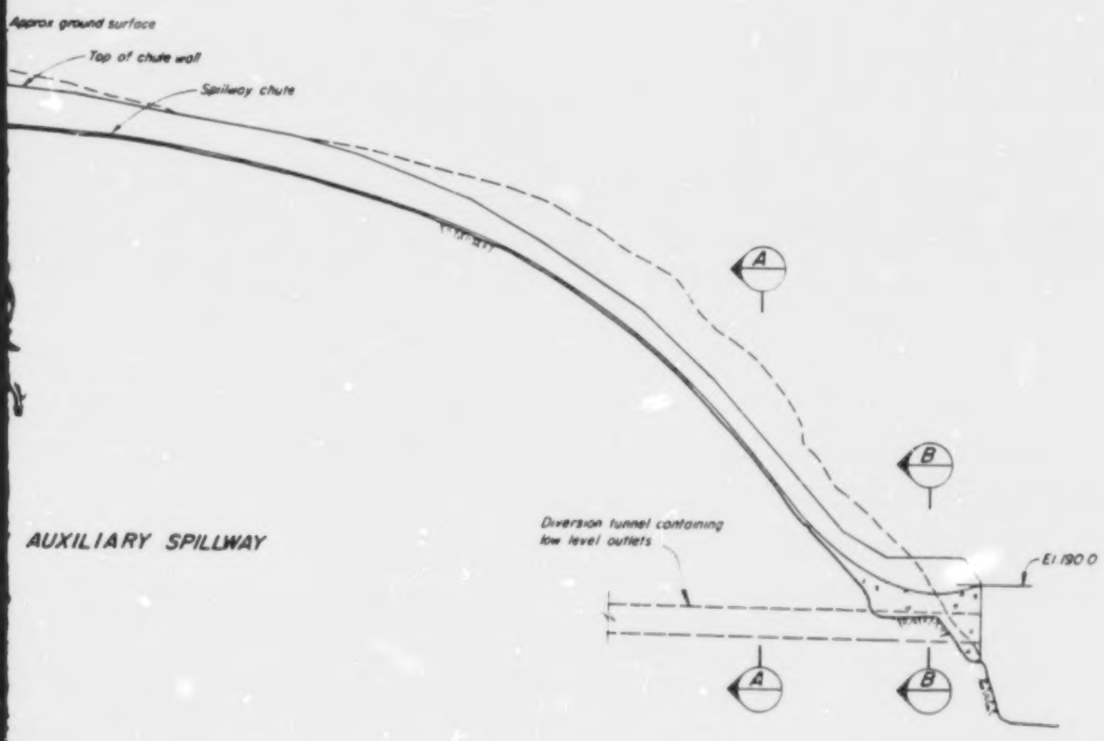
REPORT No. H1720


Gantry crane
Hoist house
Max flood level El 350.0
El 350.0
2 Radial gates 17.0 m wide x 13.8 m high
Approx ground surface
Top of chute wall
Spillway chute
El 333.8
El 326.0
Grout curtain
Drain holes

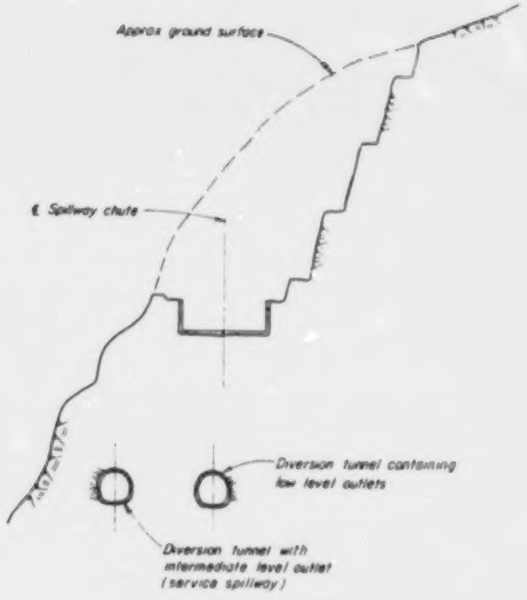
SECTION THROUGH AUXILIARY SPILLWAY


Max normal reservoir level El 347.0
Min reservoir level El 312.0
Trash rack
El 282.0
Rock trap
Air shaft
El 197.0
El 190.7
Approx riverbed level
8.4m Dia horseshoe diversion tunnel, conc
Construction rock plug removed for diversion
Closure gate 7.5m wide x 7.5m high

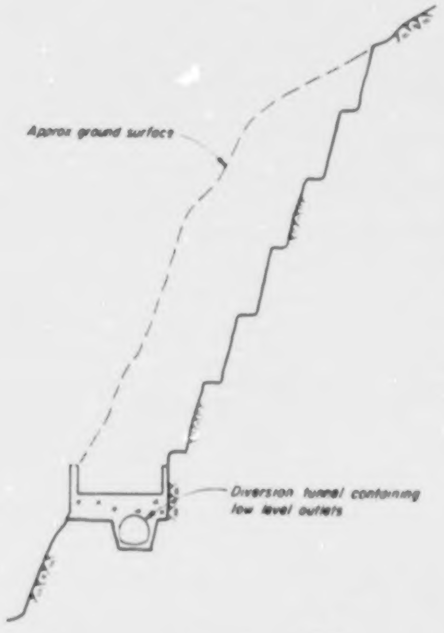
SECTION THROUGH DIVERSION TU


Approx ground surface
Top of chute wall
Spillway chute
A
B
Diversion tunnel containing low level outlets
El 190.0
A
B

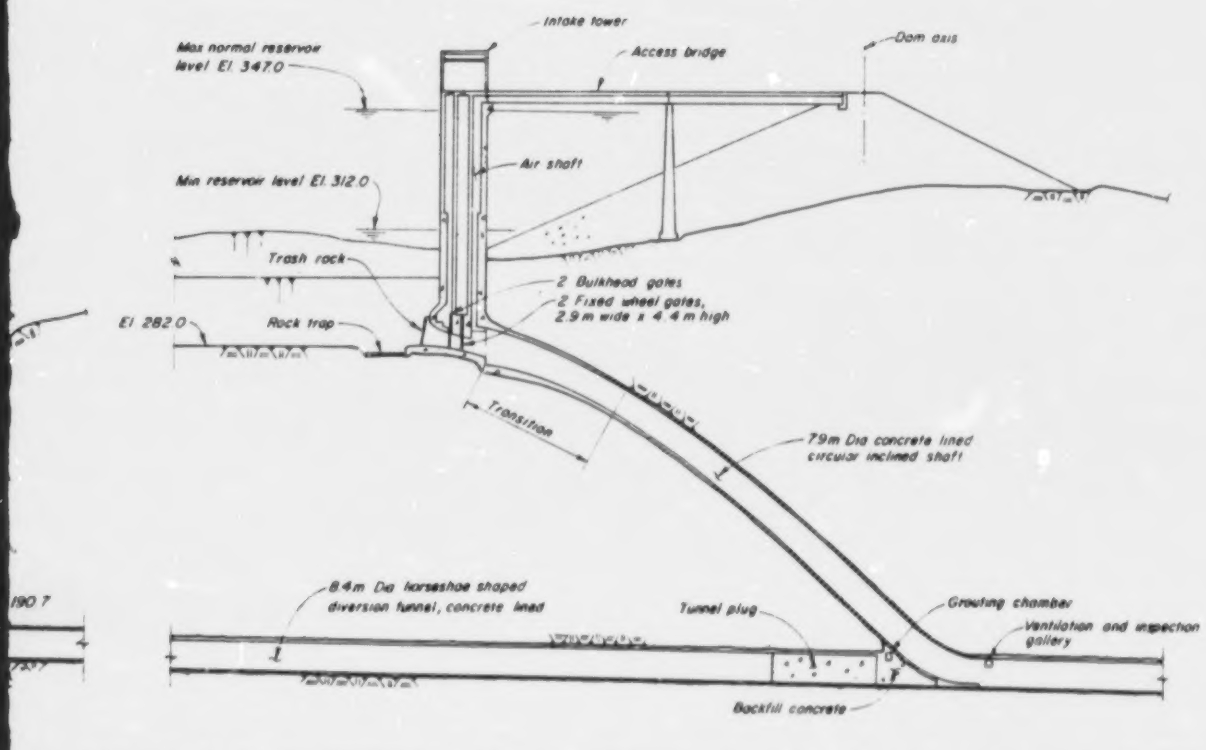
AUXILIARY SPILLWAY

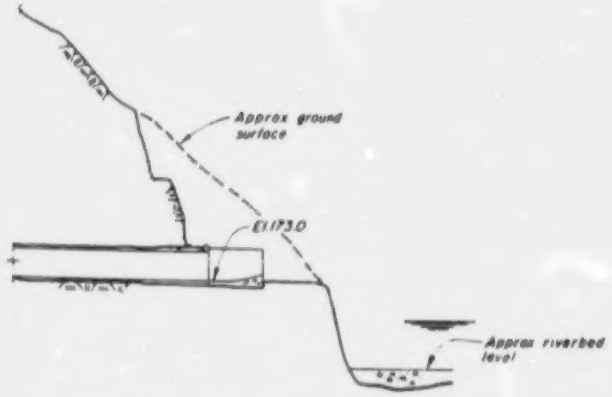

Approx ground surface
℄ Spillway chute
Diversion tunnel containing low level outlets
Diversion tunnel with intermediate level outlet (service spillway)

SECTION (A)


Approx ground surface
Diversion tunnel containing low level outlets

SECTION (B)


Intake tower
Access bridge
Dam axis
Max normal reservoir level El. 347.0
Air shaft
Min reservoir level El. 312.0
Trash rack
2 Bulkhead gates
2 Fixed wheel gates, 2.9 m wide x 4.4 m high
El 282.0
Rock trap
Transition
7.9m Dia concrete lined circular inclined shaft
190.7
8.4m Dia horseshoe shaped diversion tunnel, concrete lined
Tunnel plug
Grouting chamber
Ventilation and inspection gallery
Backfill concrete


Approx ground surface
El 173.0
Approx riverbed level

SECTION THROUGH DIVERSION TUNNEL & INTERMEDIATE LEVEL OUTLET (SERVICE SPILLWAY)

Scale: 20 0 20 40 60 80 Metres

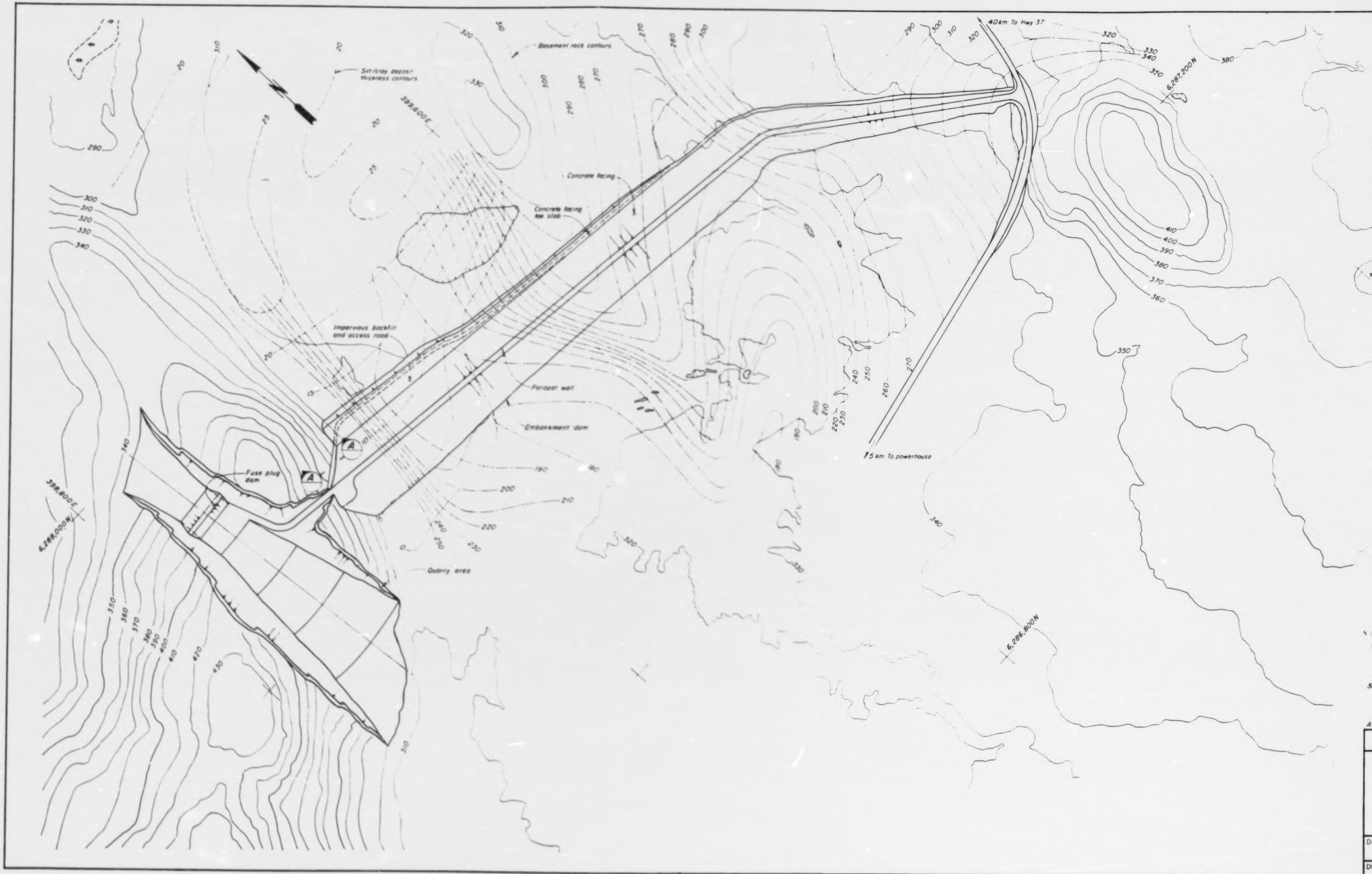
All dimensions are in metres, unless otherwise shown

BRITISH COLUMBIA HYDRO AND POWER AUTHORITY

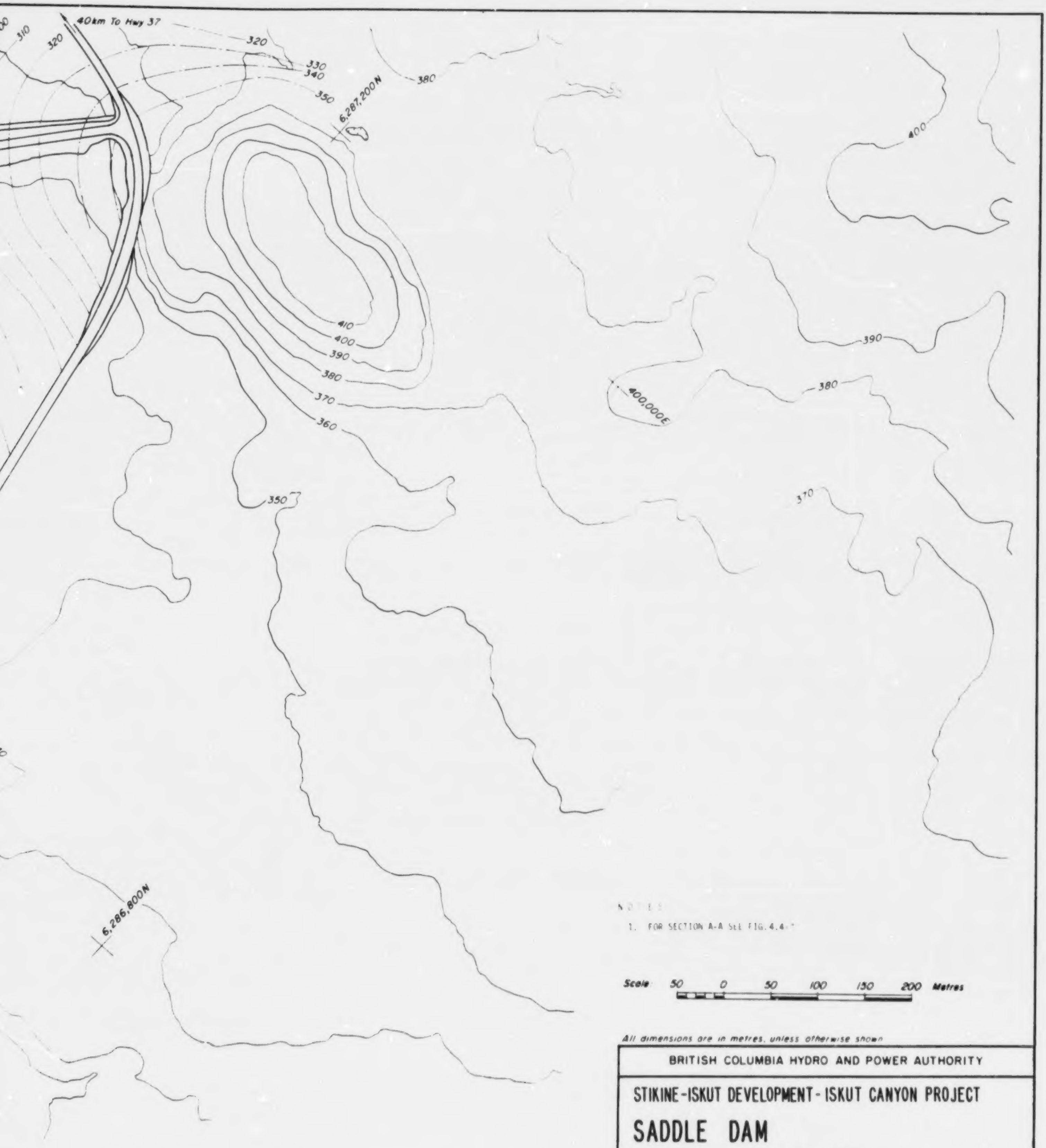
STIKINE - ISKUT DEVELOPMENT - ISKUT CANYON PROJECT
FEATURED ARRANGEMENT
LAYOUT WITH CORE EMBANKMENT DAM
SECTIONS

DATE DEC 1984	FIG. 3 - 14
DWN CY	DWG No 913 - C14 - C473

REPORT No H1720



N
Silt/clay deposit thickness contours
Basement rock contours
399,600E
398,800E
6,288,000N
6,287,200N
6,286,800N
40km To Hwy 37
5 km To powerhouse
Concrete facing
Concrete facing toe slab
Impervious backfill and access road
Parapet wall
Embankment dam
Fuse plug dam
Quarry area
A
A
290
300
310
320
330
340
350
360
370
380
390
400
410
420
430
270
280
260
250
240
230
220
210
200
190
180
10
15
20
25
0


40km To Hwy 37
310
320
320
330
340
350
380
6,287,200N
400
410
400
390
380
370
360
350
390
380
400,000E
370
6,286,800N
Scale 50 0 50 100 150 200 Metres

NOTES

1. FOR SECTION A-A SEE FIG. 4.4-[illegible]

All dimensions are in metres, unless otherwise shown

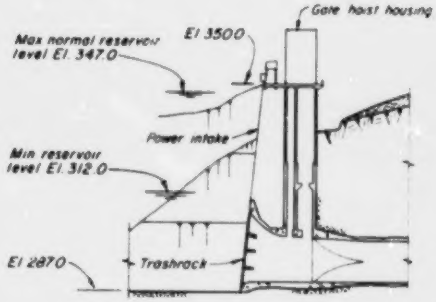
BRITISH COLUMBIA HYDRO AND POWER AUTHORITY

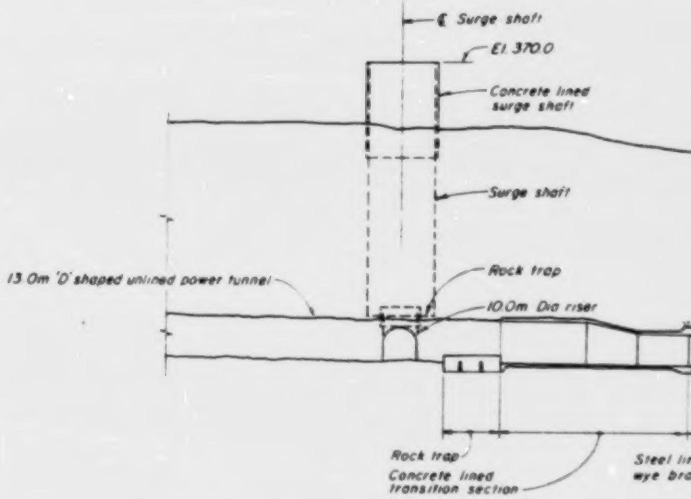
STIKINE-ISKUT DEVELOPMENT - ISKUT CANYON PROJECT

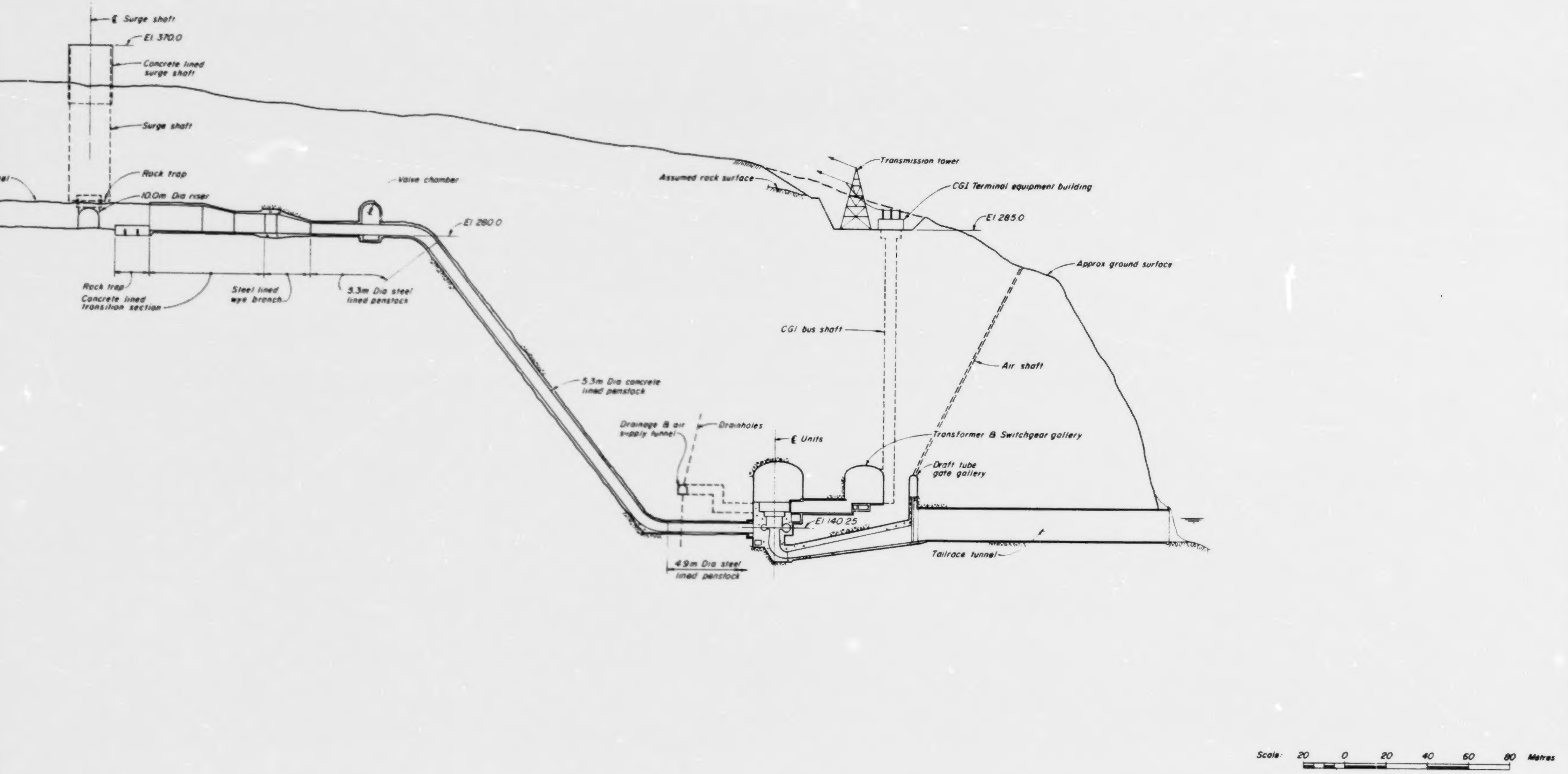
SADDLE DAM
GENERAL ARRANGEMENT

DATE DEC 1984	FIG. 3 - 15
DWN CY	DWG No 913-C14-C474

REPORT No H1720


Gate hoist housing
Max normal reservoir level El. 347.0
El 350.0
Power intake
Min reservoir level El. 312.0
El 287.0
Trashrack


℄ Surge shaft
El. 370.0
Concrete lined surge shaft
Surge shaft
Rock trap
13.0m 'D' shaped unlined power tunnel
10.0m Dia riser
Rock trap
Concrete lined transition section
Steel lin
wye bra



℄ Surge shaft
El 370.0
Concrete lined surge shaft
Surge shaft
Rock trap
10.0m Dia riser
Valve chamber
El 280.0
Rock trap
Concrete lined transition section
Steel lined wye branch
5.3m Dia steel lined penstock
5.3m Dia concrete lined penstock
Drainage & air supply tunnel
Drainholes
℄ Units
4.9m Dia steel lined penstock
El 140.25
Tailrace tunnel
Transmission tower
Assumed rock surface
CGI Terminal equipment building
El 285.0
Approx ground surface
CGI bus shaft
Air shaft
Transformer & Switchgear gallery
Draft tube gate gallery
Scale: 20 0 20 40 60 80 Metres

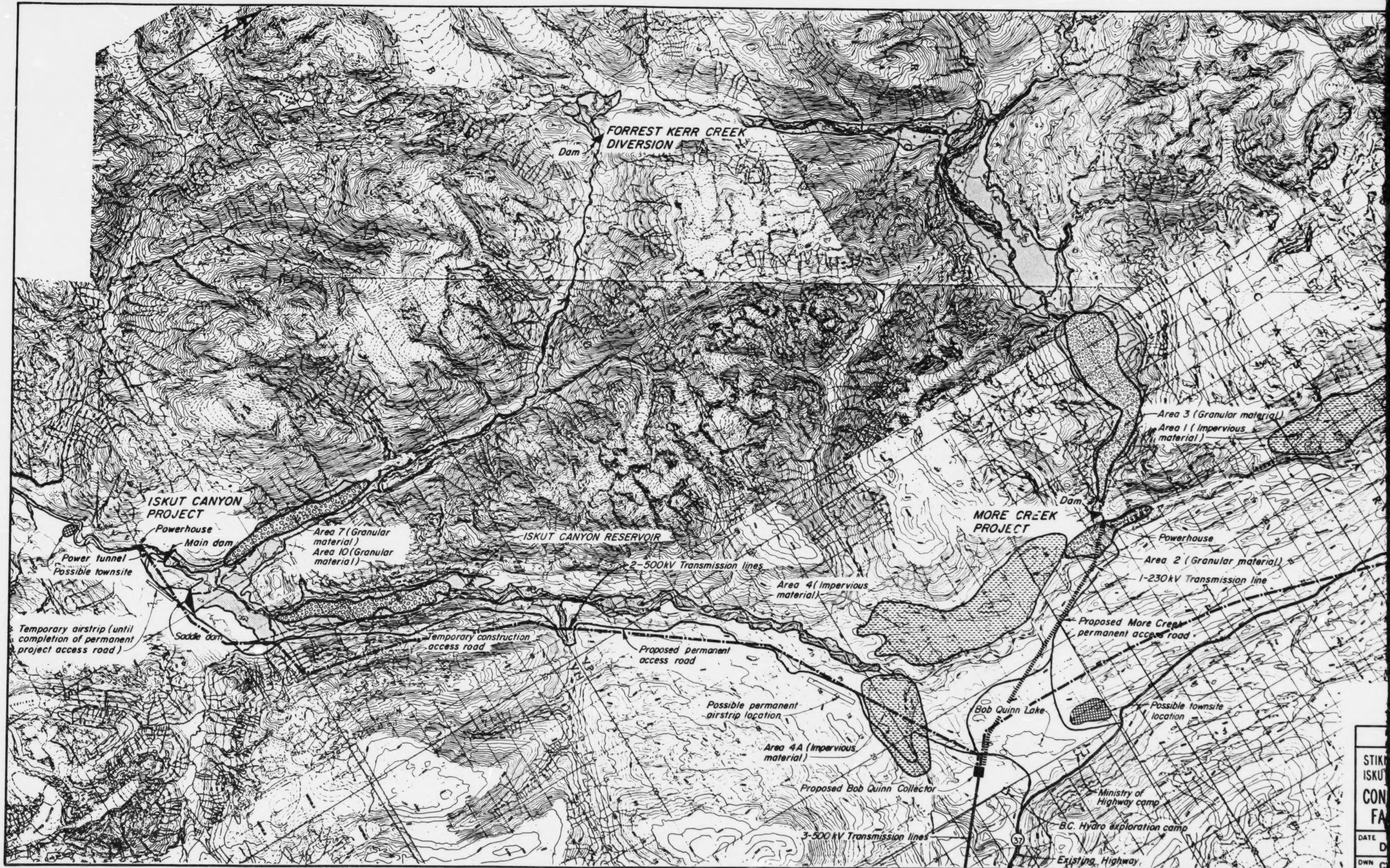
BRITISH COLUMBIA HYDRO AND POWER AUTHORITY

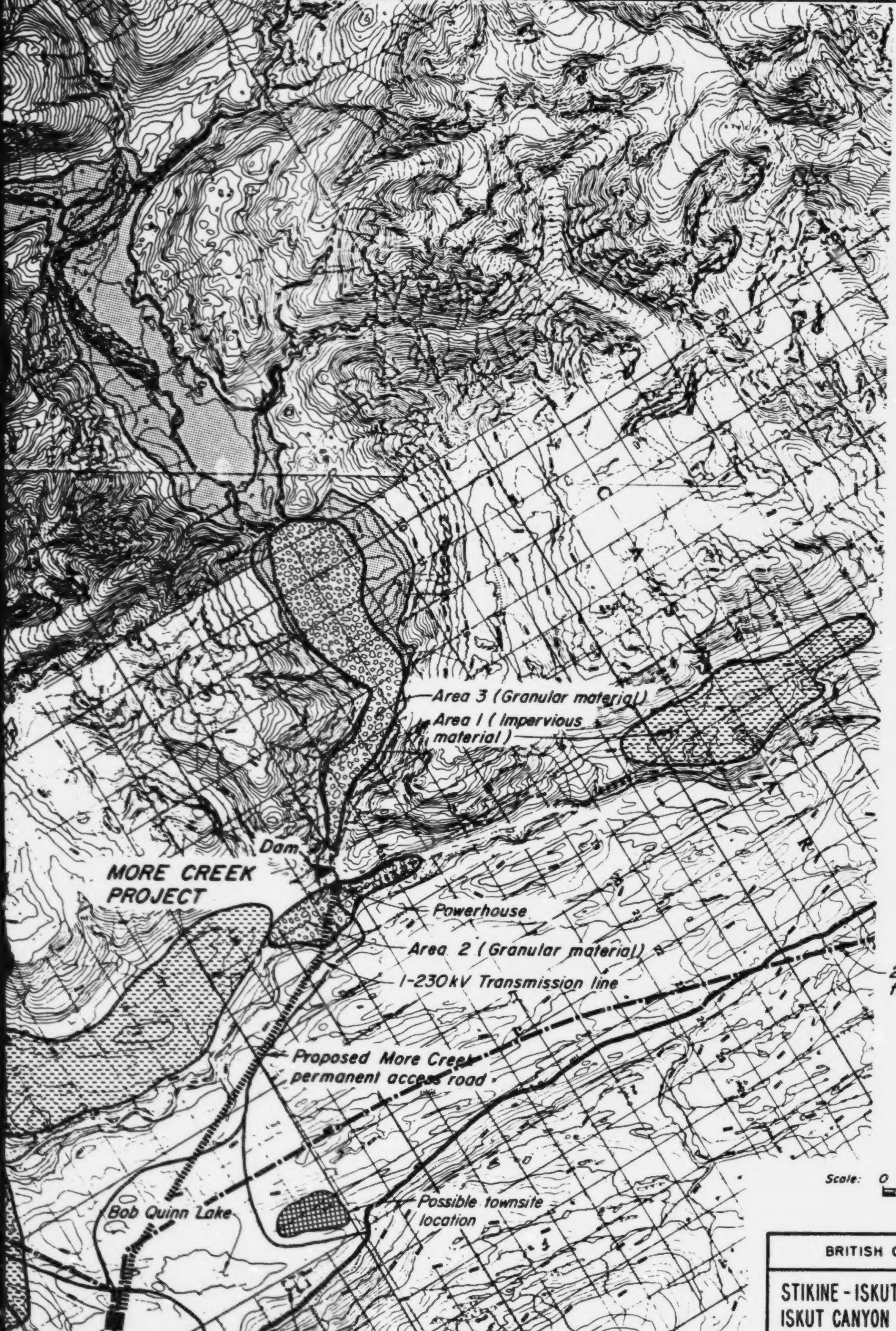
STIKINE - ISKUT DEVELOPMENT - ISKUT CANYON PROJECT

POWER FACILITIES
PROFILE

DATE DEC 1984	FIG. 3-16
DWN PSK	DWG No 913-C14-C475

REPORT No H1720


FORREST KERR CREEK DIVERSION
Dam
ISKUT CANYON PROJECT
Powerhouse
Main dam
Power tunnel
Possible townsite
Temporary airstrip (until completion of permanent project access road)
Saddle dam
Area 7 (Granular material)
Area 10 (Granular material)
ISKUT CANYON RESERVOIR
2-500kV Transmission lines
Temporary construction access road
Proposed permanent access road
Possible permanent airstrip location
Area 4 (Impervious material)
Area 4A (Impervious material)
Proposed Bob Quinn Collector
3-500kV Transmission lines
Bob Quinn Lake
MORE CREEK PROJECT
Dam
Area 3 (Granular material)
Area 1 (Impervious material)
Powerhouse
Area 2 (Granular material)
1-230kV Transmission line
Proposed More Creek permanent access road
Possible townsite location
Ministry of Highway camp
B.C. Hydro exploration camp
37
Existing Highway
STIK
ISKU
CON
FA
DATE
D
DWN


Area 3 (Granular material)
Area 1 (Impervious material)
Dam
MORE CREEK PROJECT
Powerhouse
Area 2 (Granular material)
1-230kV Transmission line
2-500kV Transmission lines. from Stikine Collector
Proposed More Creek permanent access road
Possible townsite location
Bob Quinn Lake
Ministry of Highway camp
B.C. Hydro exploration camp
37
Existing Highway
Scale: 0 1 2 3 4 5 6 Kilometers

NOTES:

1. THE BOUNDARIES OF THE BORROW AREAS ARE APPROXIMATE ONLY.

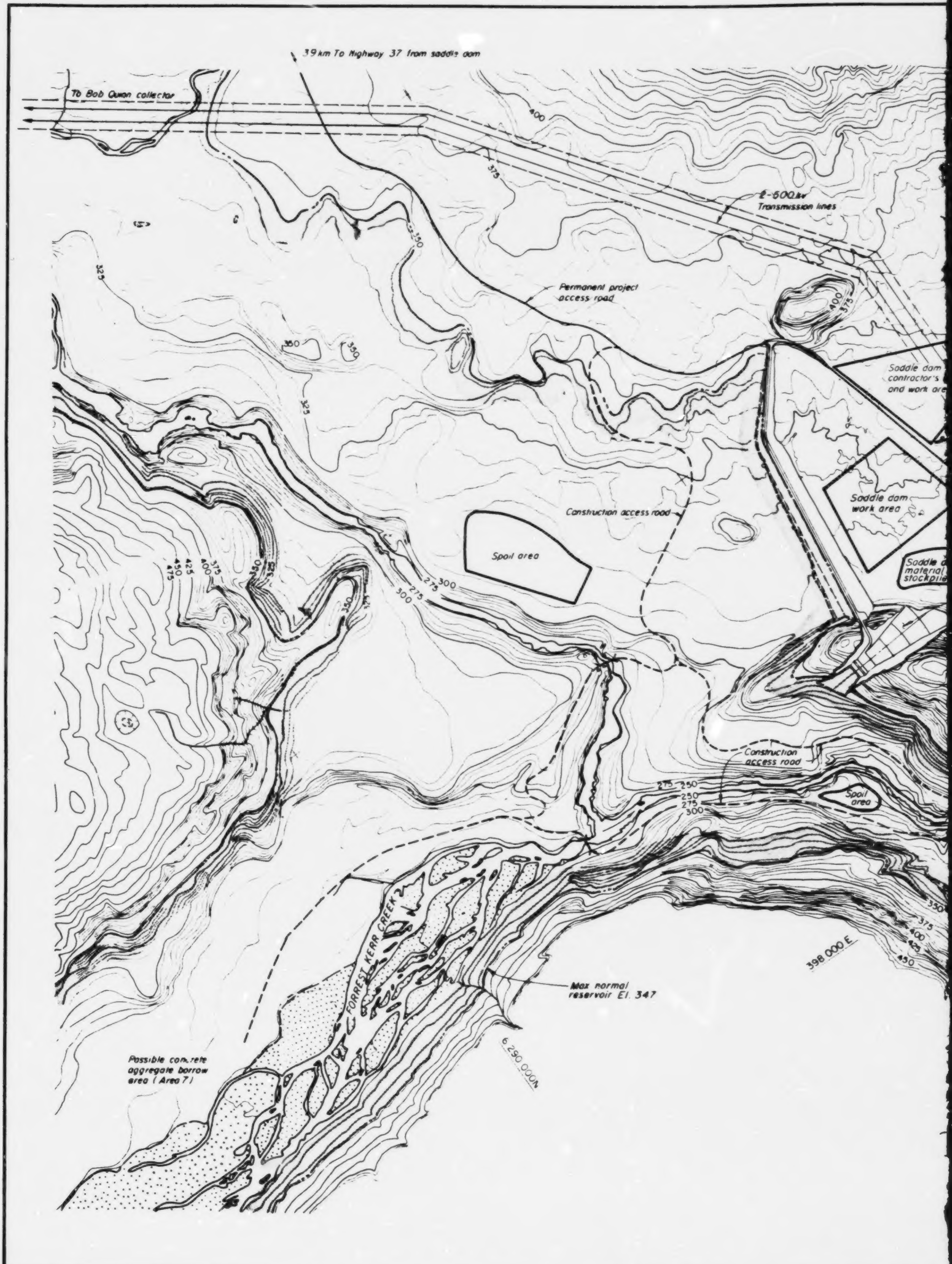
BRITISH COLUMBIA HYDRO AND POWER AUTHORITY

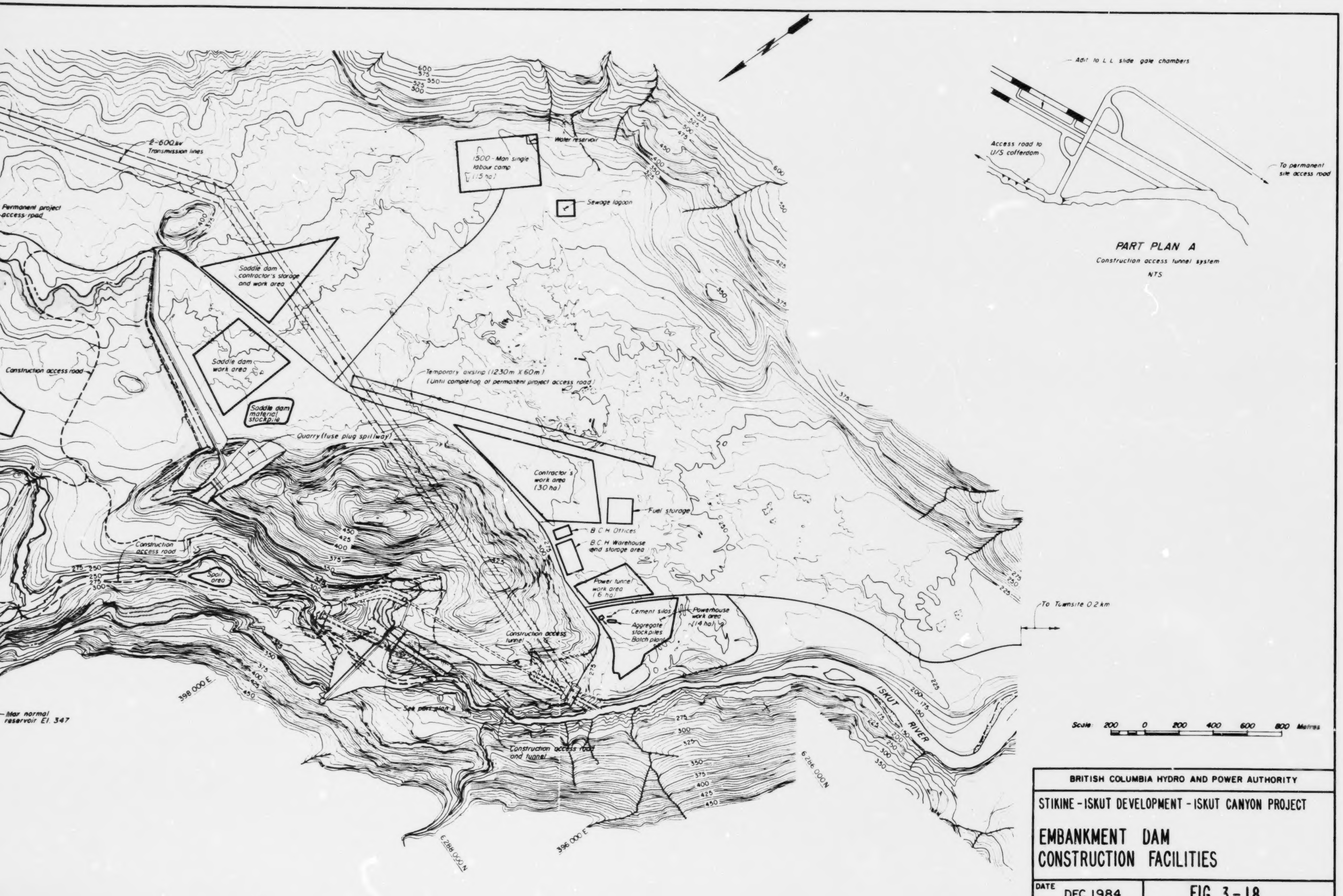
STIKINE - ISKUT DEVELOPMENT
ISKUT CANYON & MORE CREEK PROJECTS

CONSTRUCTION ACCESS & FACILITIES

DATE DEC 1984	FIG. 3 - 17
DWN CY / PK	DWG No. 913 - C14 - C476

REPORT No. H1720


39 km To Highway 37 from saddle dam
To Bob Quon collector
2-500 kv Transmission lines
Permanent project access road
Saddle dam contractor's and work are
Saddle dam work area
Saddle d material stockpile
Construction access road
Spoil area
Construction access road
Spoil area
Max normal reservoir El. 347
FORREST KERR CREEK
Possible concrete aggregate borrow area (Area 7)
398 000 E
6 290 000 N
400
375
350
325
300
275
250
425
450
475

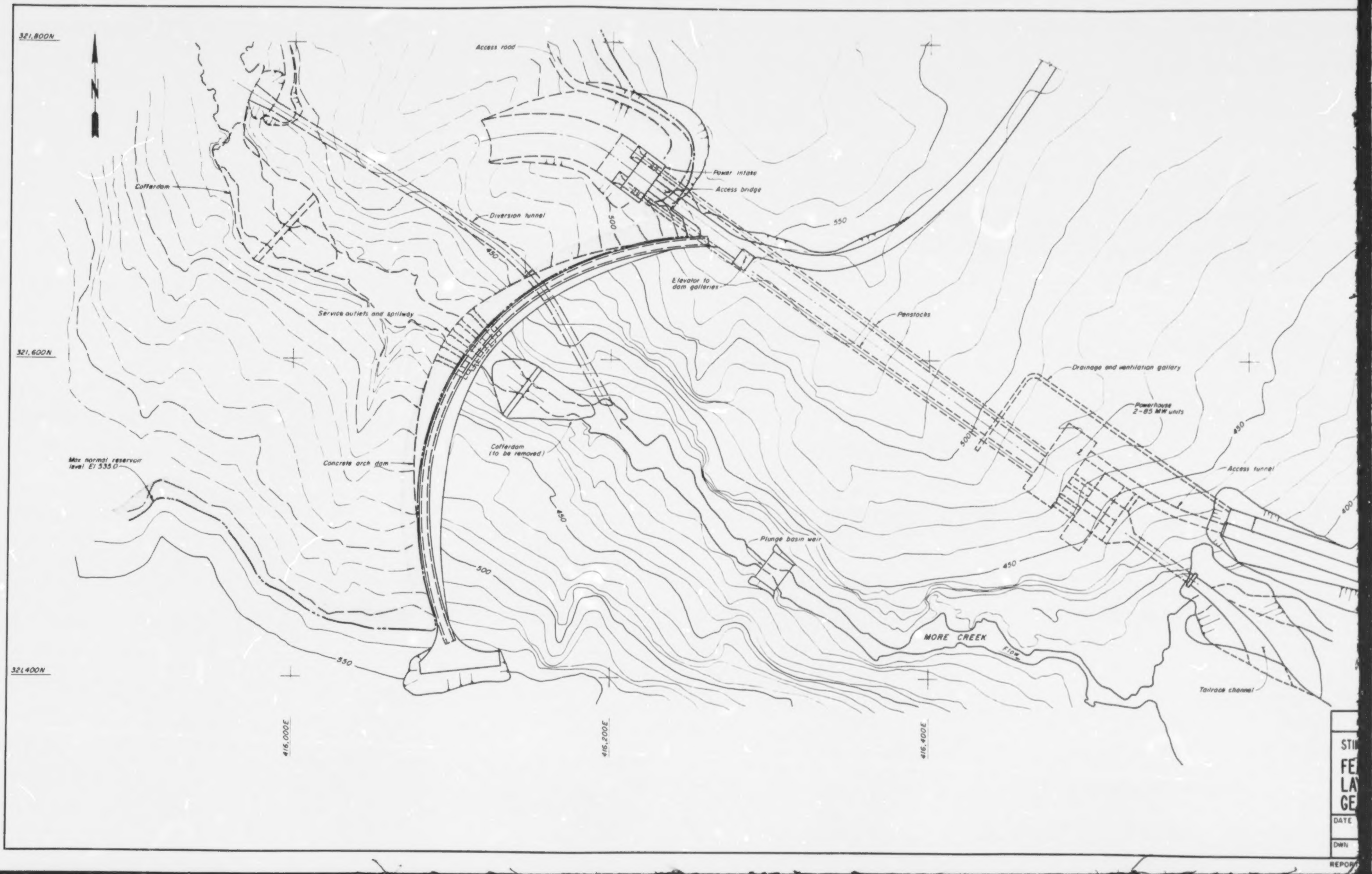

2-600 kv Transmission lines
Permanent project access road
Construction access road
1500 - Man single labour camp (15 ha)
Water reservoir
Sewage lagoon
Saddle dam contractor's storage and work area
Saddle dam work area
Saddle dam material stockpile
Quarry (fuse plug spillway)
Temporary airstrip (1230 m X 60 m) (Until completion of permanent project access road)
Contractor's work area (30 ha)
Fuel storage
B.C.H. Offices
B.C.H. Warehouse and storage area
Power tunnel work area (6 ha)
Cement silos
Aggregate stockpiles
Batch plant
Powerhouse work area (14 ha)
Construction access road
Spoil area
Construction access tunnel
See part plan A
Construction access road and tunnel
To Townsite 0.2 km
ISKUT RIVER
Max normal reservoir El. 347
398 000 E
396 000 E
6 288 000 N
6 286 000 N
600
575
550
525
500
475
450
425
400
375
350
325
300
275
250
225
200
175
150
Adit to L.L. slide gate chambers
Access road to U/S cofferdam
To permanent site access road
PART PLAN A
Construction access tunnel system
NTS
Scale 200 0 200 400 600 800 Metres

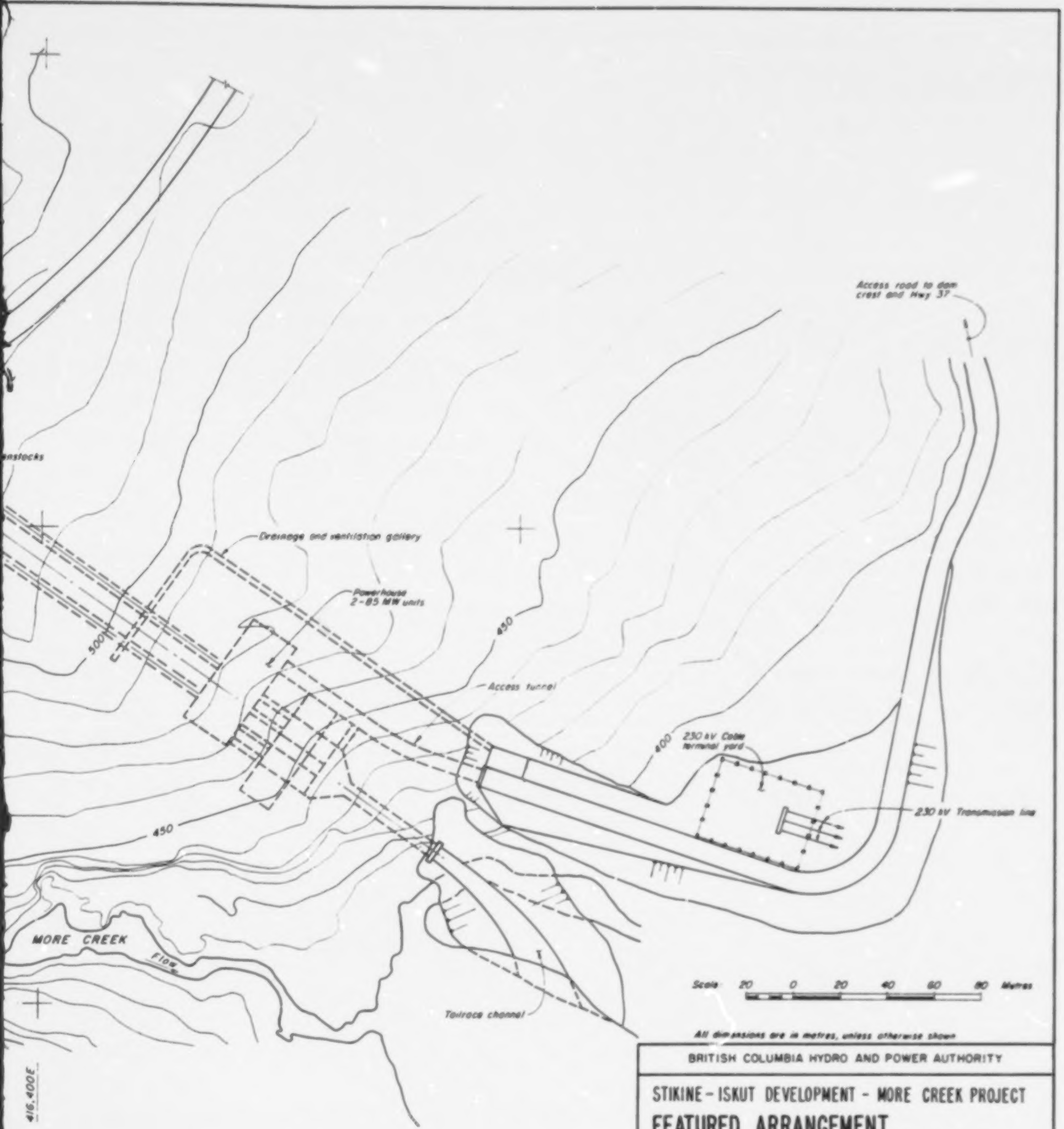
BRITISH COLUMBIA HYDRO AND POWER AUTHORITY

STIKINE - ISKUT DEVELOPMENT - ISKUT CANYON PROJECT

EMBANKMENT DAM CONSTRUCTION FACILITIES

DATE DEC 1984
FIG. 3-18
DWN CY
DWG No 913-C14-C477
REPORT No. H1720


321,800N
N
Access road
Cofferdam
Diversion tunnel
450
500
Power intake
Access bridge
550
Elevator to
dam galleries
Service outlets and spillway
Penstocks
321,600N
Drainage and ventilation gallery
Powerhouse
2-85 MW units
450
500
Access tunnel
400
Max normal reservoir
level El 535.0
Concrete arch dam
Cofferdam
(to be removed)
450
Plunge basin weir
450
500
MORE CREEK
Flow
550
321,400N
Tailrace channel
416,000E
416,200E
416,400E
STI
FE
LA
GE
DATE
DWN
REPOR


Access road to dam crest and Hwy 37
enstocks
Drainage and ventilation gallery
Powerhouse
2-85 MW units
500
450
Access tunnel
400
230 kV Cable terminal yard
230 kV Transmission line
450
MORE CREEK
Flow
Tailrace channel
416,400E
Scale 20 0 20 40 60 80 Metres

All dimensions are in metres, unless otherwise shown

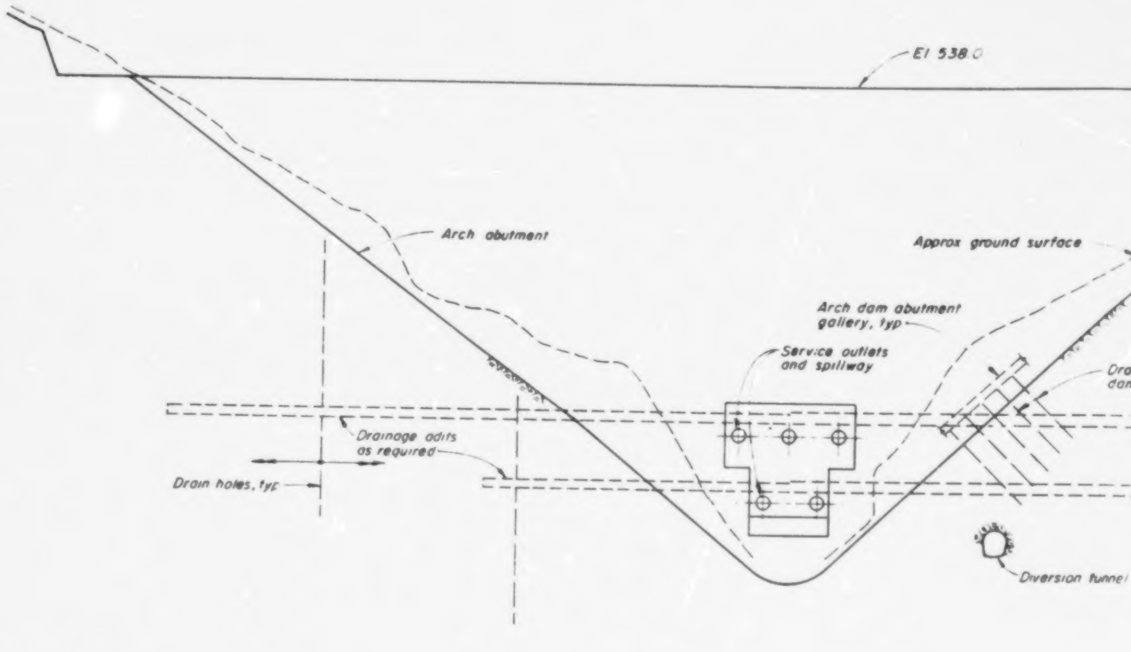
BRITISH COLUMBIA HYDRO AND POWER AUTHORITY

STIKINE - ISKUT DEVELOPMENT - MORE CREEK PROJECT

FEATURED ARRANGEMENT
LAYOUT WITH CONCRETE ARCH DAM
GENERAL ARRANGEMENT

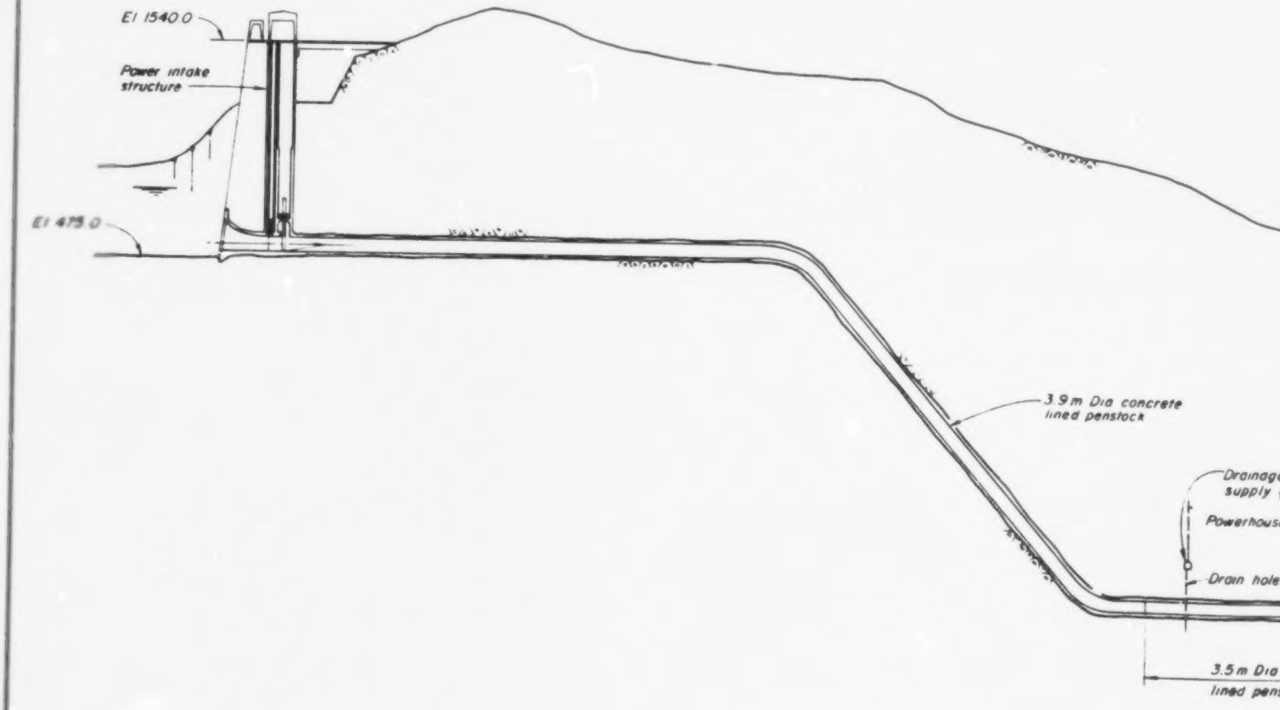
DATE DEC 1984	FIG. 3 - 19
DWN PSK	DWG No 913-C14-C478

REPORT No H1720

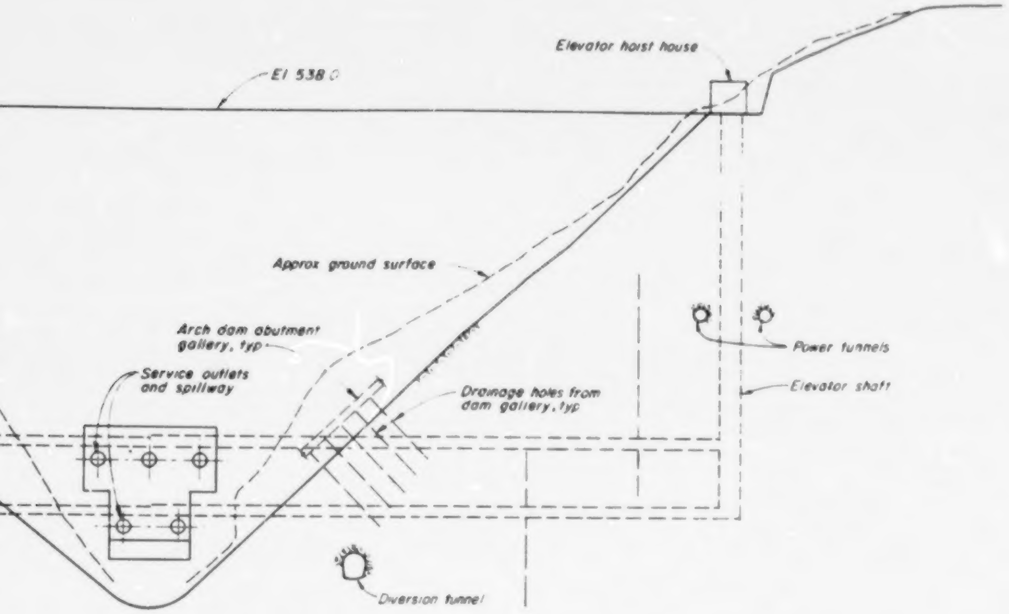

El 538.0
Arch abutment
Approx ground surface
Arch dam abutment gallery, typ
Service outlets and spillway
Dra
dan
Drainage adits as required
Drain holes, typ
Diversion tunnel

DEVELOPED DOWNSTREAM ELEVATION

(Grout curtain not shown)

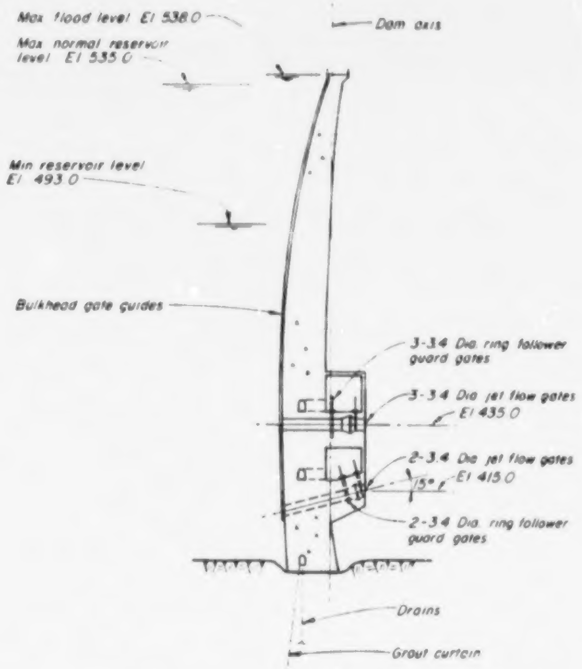

El 1540.0
Power intake structure
El 475.0
3.9 m Dia concrete lined penstock
Drainage
supply
Powerhouse
Drain hole
3.5 m Dia
lined pens

SECTION THROUGH POWER FACILITIES



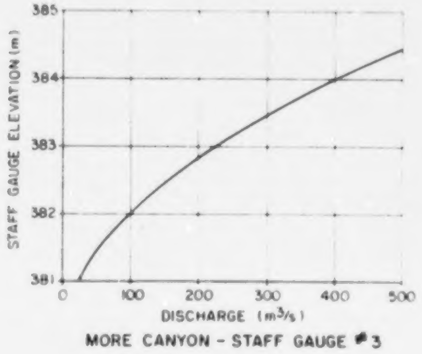
El 538.0
Elevator hoist house
Approx ground surface
Arch dam abutment gallery, typ
Service outlets and spillway
Drainage holes from dam gallery, typ
Power tunnels
Elevator shaft
Diversion tunnel

VELOPED DOWNSTREAM ELEVATION
(Grout curtain not shown)

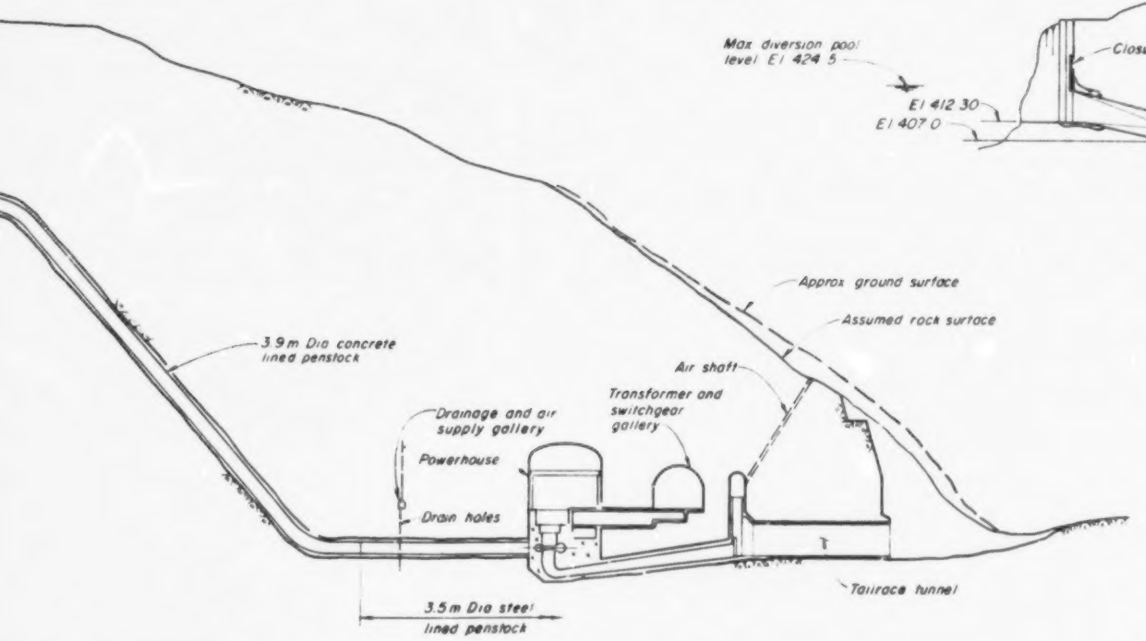


Max flood level El 538.0
Dam axis
Max normal reservoir level El 535.0
Min reservoir level El 493.0
Bulkhead gate guides
3-3.4 Dia ring follower guard gates
3-3.4 Dia jet flow gates
El 435.0
2-3.4 Dia jet flow gates
15°
El 415.0
2-3.4 Dia ring follower guard gates
Drains
Grout curtain

SECTION THROUGH CONCRETE ARCH DAM

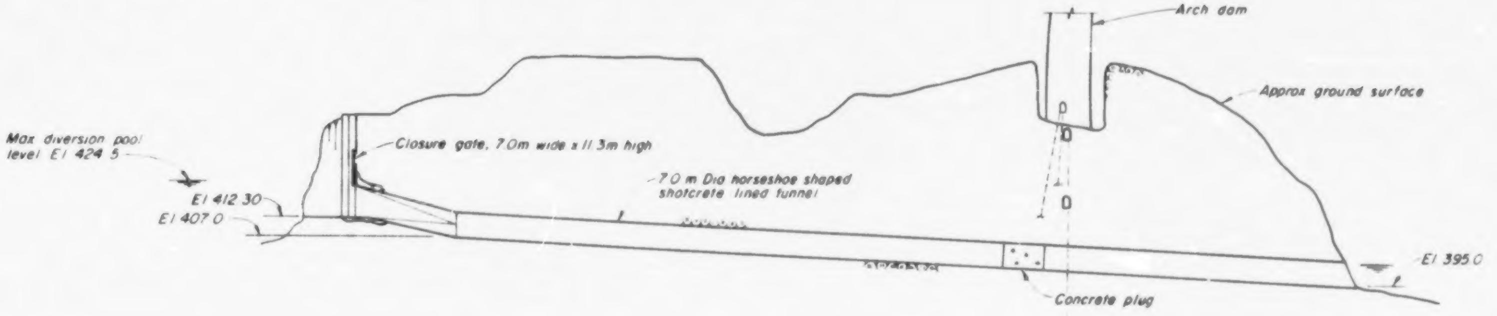


DISCHARGE RATING CURVE FOR POWERHOUSE TAILRACE



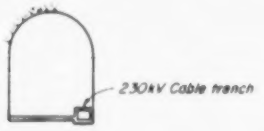
Approx ground surface
Assumed rock surface
3.9 m Dia concrete lined penstock
Air shaft
Transformer and switchgear gallery
Drainage and air supply gallery
Powerhouse
Drain holes
Tailrace tunnel
3.5 m Dia steel lined penstock

ECTION THROUGH POWER FACILITIES



Arch dam
Approx ground surface
Max diversion pool level El 424.5
Closure gate, 7.0 m wide x 11.3 m high
7.0 m Dia horseshoe shaped shotcrete lined tunnel
El 412.30
El 407.0
El 395.0
Concrete plug

SECTION THROUGH DIVERSION TUNNEL



230 kV Cable trench

TYPICAL SECTION THROUGH ACCESS TUNNEL
NTS

Scale 20 0 20 40 60 80 Metres

All dimensions are in metres, unless otherwise shown

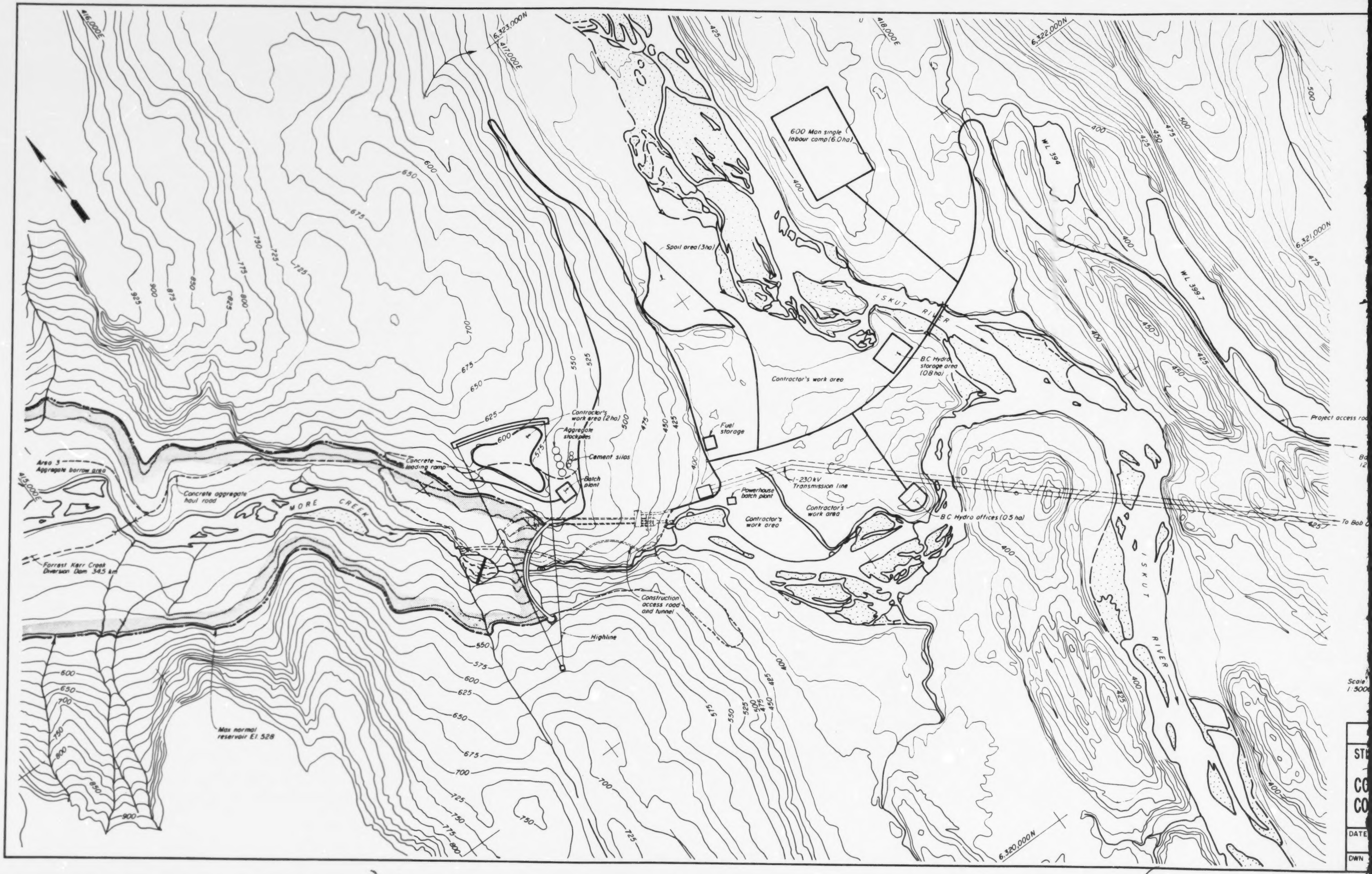
BRITISH COLUMBIA HYDRO AND POWER AUTHORITY

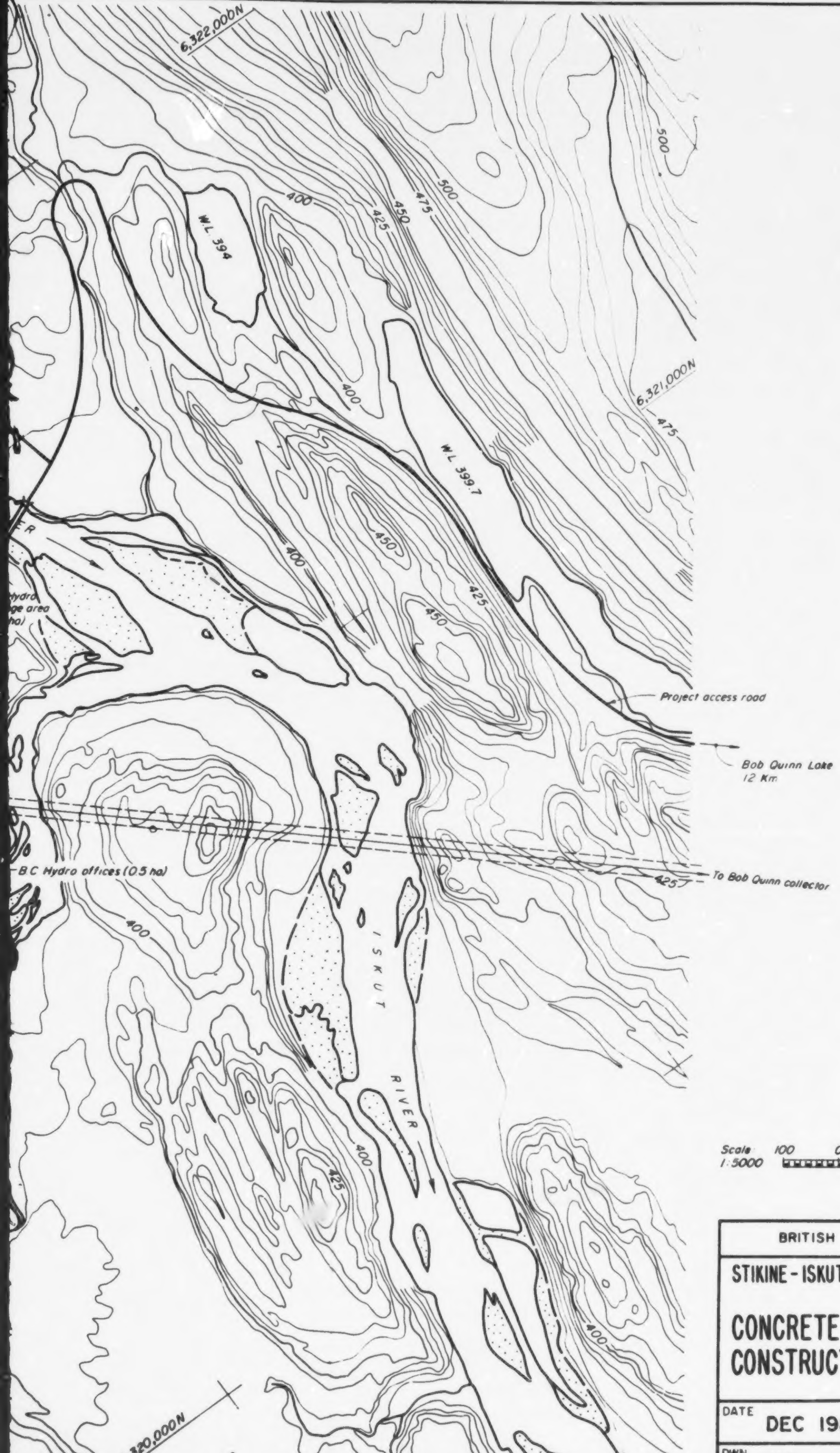
STIKINE - ISKUT DEVELOPMENT - MORE CREEK PROJECT

FEATURED ARRANGEMENT
LAYOUT WITH CONCRETE ARCH DAM
ELEVATION & SECTIONS

DATE DEC 1984	FIG. 3-20
DWN PSK	DWG No 913-C14-C479

REPORT No H1720


600 Man single labour camp (6.0 ha)
Spoil area (3 ha)
ISKUT RIVER
B.C. Hydro storage area (0.8 ha)
Contractor's work area
Project access road
Contractor's work area (2 ha)
Aggregate stockpiles
Cement silos
Batch plant
Fuel storage
Concrete loading ramp
Area 3 Aggregate borrow area
Concrete aggregate haul road
MORE CREEK
1-230 kV Transmission line
Powerhouse batch plant
Contractor's work area
Contractor's work area
B.C. Hydro offices (0.5 ha)
To Bob Q
Forrest Kerr Creek Diversion Dam 34.5 km
Construction access road and tunnel
Highline
Max normal reservoir El. 528
ISKUT RIVER
WL 394
WL 399.7
6,323,000N
417,000E
416,000E
418,000E
6,322,000N
6,321,000N
415,000E
6,320,000N
Scale 1:5000
ST
CO
CO
DATE
DWN
REPOR


6,322,000N
6,321,000N
6,320,000N
WL 394
WL 399.7
400
425
450
475
500
ER
Hydro
ge area
ha)
Project access road
Bob Quinn Lake
12 Km
B C Hydro offices (0.5 ha)
To Bob Quinn collector
ISKUT
RIVER
Scale 1:5000
100 0 100 200 300 400 Metres

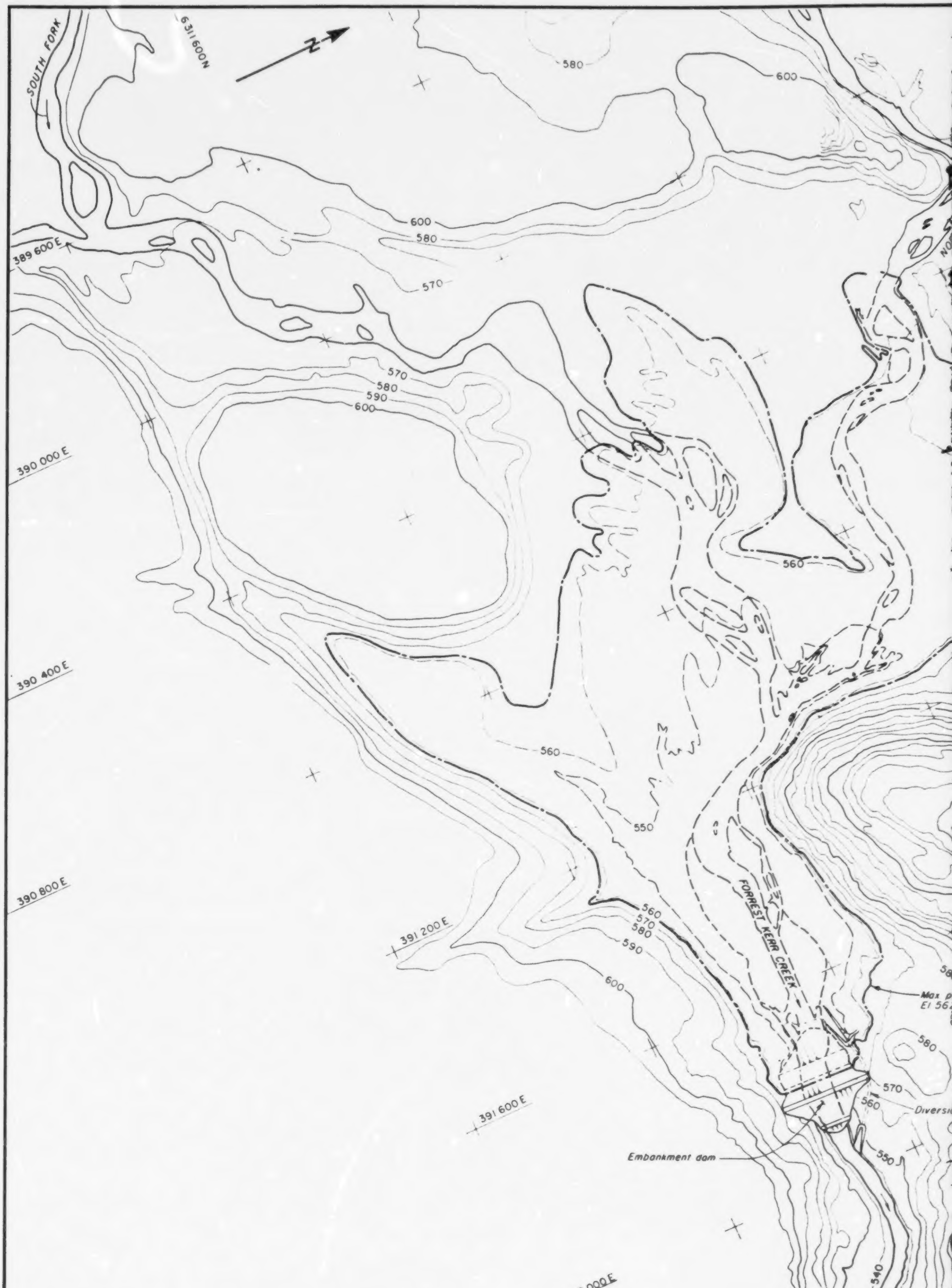
BRITISH COLUMBIA HYDRO AND POWER AUTHORITY

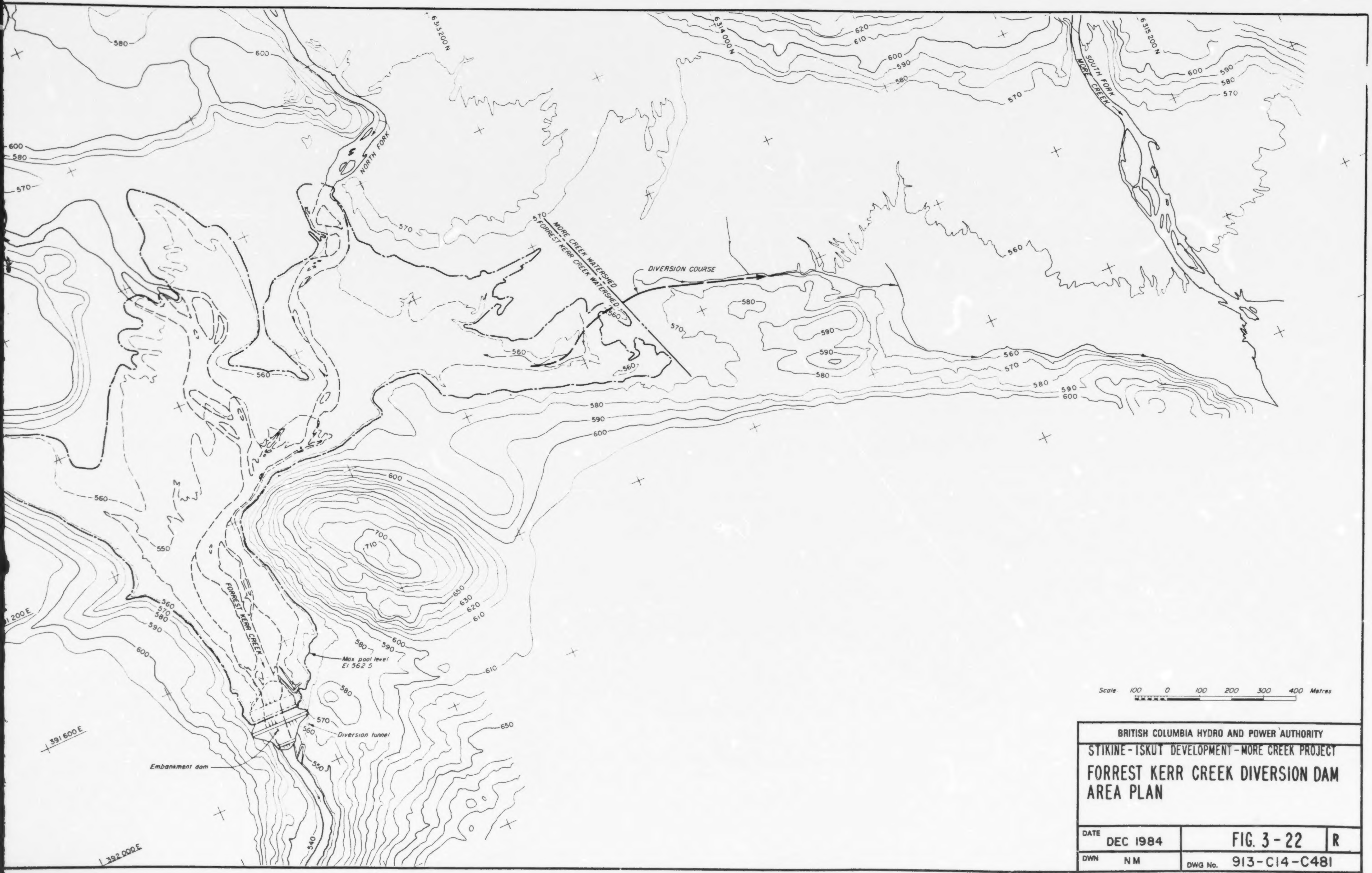
STIKINE-ISKUT DEVELOPMENT-MORE CREEK PROJECT

CONCRETE ARCH DAM
CONSTRUCTION FACILITIES

DATE DEC 1984	FIG. 3-21
DWN MJS	DWG No 913-C14-C480

REPORT No. H1720


SOUTH FORK
6311600N
N
580
600
600
580
570
389 600 E
570
580
590
600
390 000 E
390 400 E
390 800 E
560
560
550
560
570
580
590
600
391 200 E
FORREST KERR CREEK
Max p
El 56
580
570
560
Diversi
550
Embankment dam
391 600 E
540
392 000 E



6 313 200 N
6 314 000 N
6 315 200 N
NORTH FORK
SOUTH FORK
MORE CREEK
MORE CREEK WATERSHED
FORREST KERR CREEK WATERSHED
DIVERSION COURSE
FORREST KERR CREEK
Max pool level El 562.5
Diversion tunnel
Embankment dam
391 200 E
391 600 E
392 000 E
540
550
560
570
580
590
600
610
620
630
650
700
710
Scale 100 0 100 200 300 400 Metres

BRITISH COLUMBIA HYDRO AND POWER AUTHORITY

STIKINE - ISKUT DEVELOPMENT - MORE CREEK PROJECT

FORREST KERR CREEK DIVERSION DAM AREA PLAN

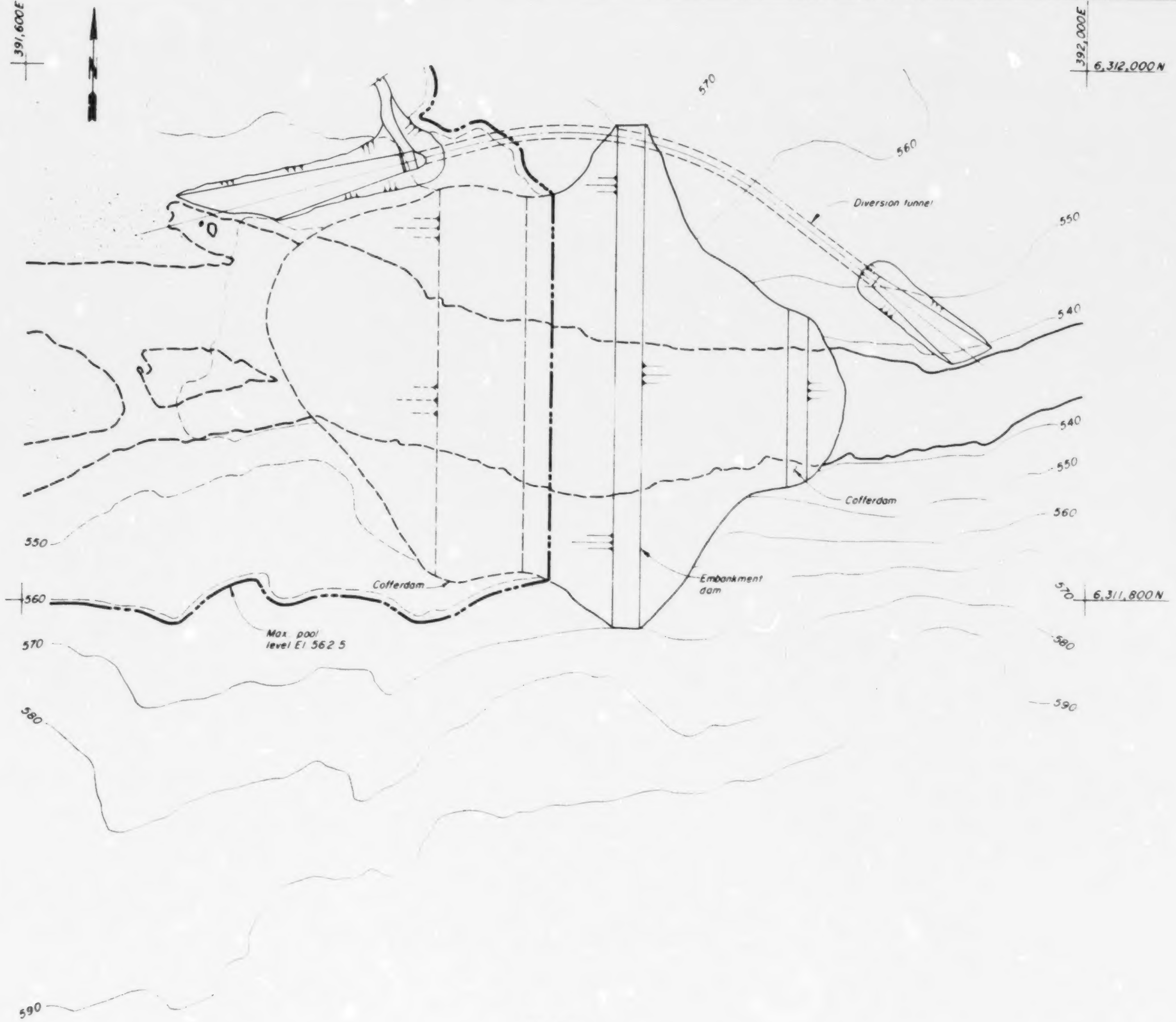
DATE DEC 1984

FIG. 3 - 22 R

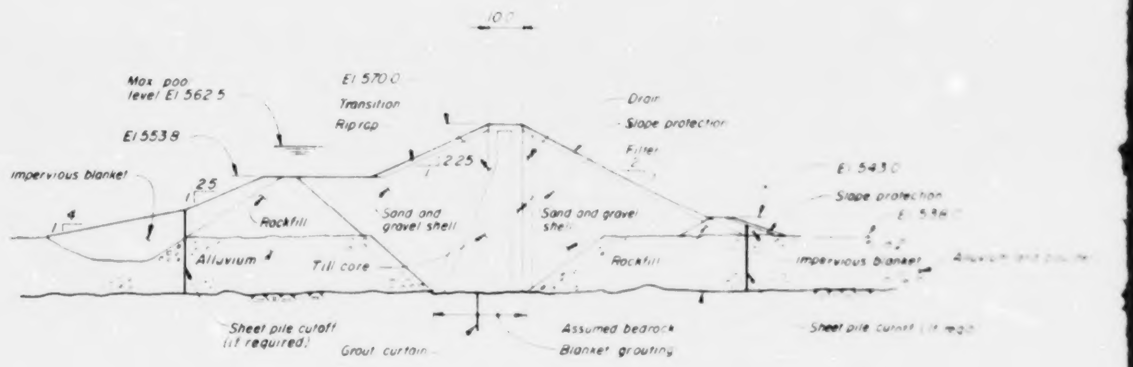
DWN NM

DWG No. 913-C14-C481

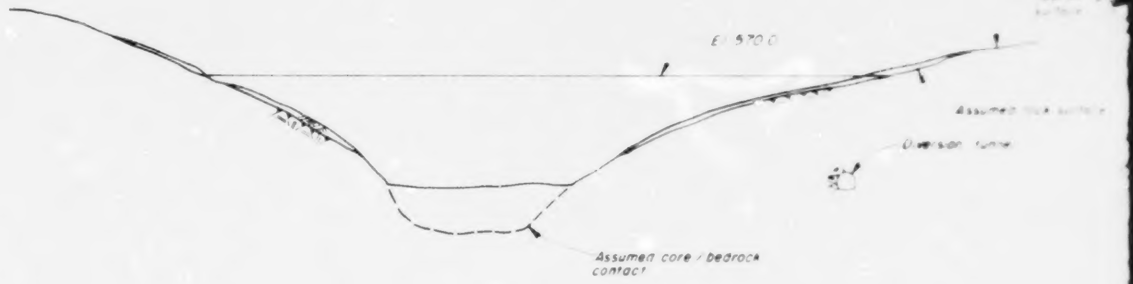
REPORT No. H 1720


391,600E
392,000E
6,312,000 N
6,311,800 N
570
560
550
540
540
550
560
570
580
590
550
560
570
580
590
Diversion tunnel
Cofferdam
Cofferdam
Embankment dam
Max. pool level El 562.5

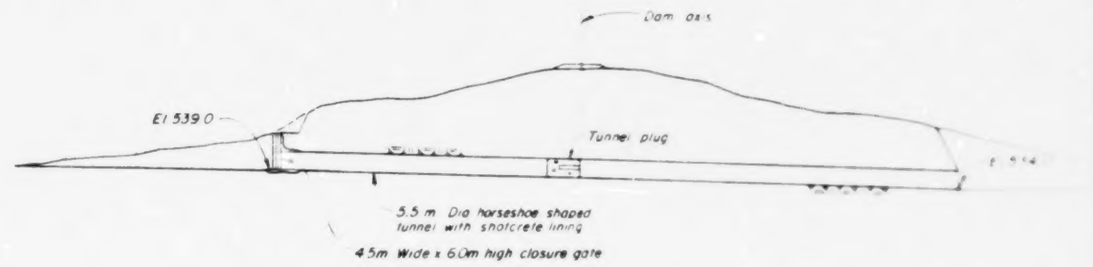
PLAN


10.0
Max. pool level El 562.5
El 570.0
Transition
Riprap
El 553.8
Drain
Slope protection
Filter
Impervious blanket
2.5
1
4
1
2.25
1
2
El 543.0
Slope protection
El 538.0
Rockfill
Sand and gravel shell
Sand and gravel shell
Alluvium
Till core
Rockfill
Impervious blanket
Alluvium and boulder
Sheet pile cutoff (if required)
Grout curtain
Assumed bedrock
Blanket grouting
Sheet pile cutoff (if reqd)

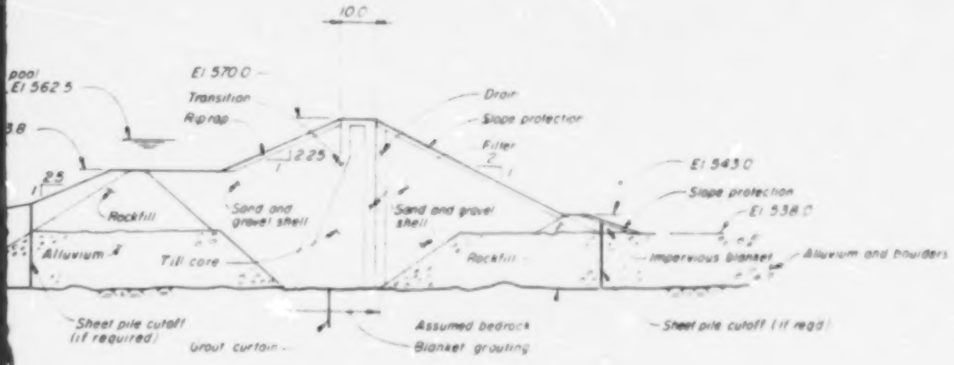
SECTION THROUGH EARTHFILL DAM


El 570.0
Assumed rock surface
Diversion tunnel
Assumed core / bedrock contact

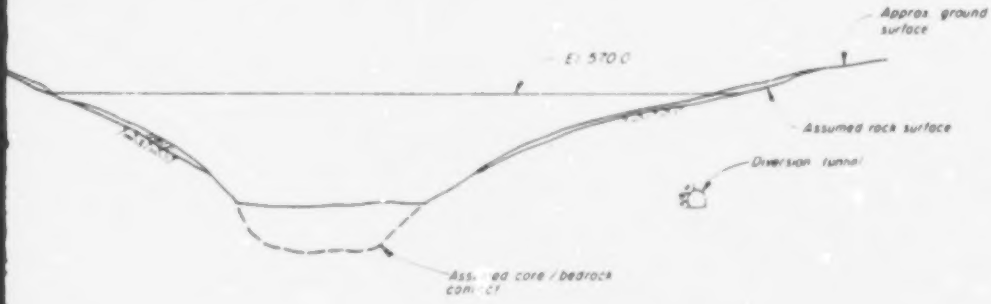
DOWNSTREAM ELEVATION


Dam axis
El 539.0
Tunnel plug
5.5 m Dia horseshoe shaped tunnel with shotcrete lining
4.5m Wide x 6.0m high closure gate

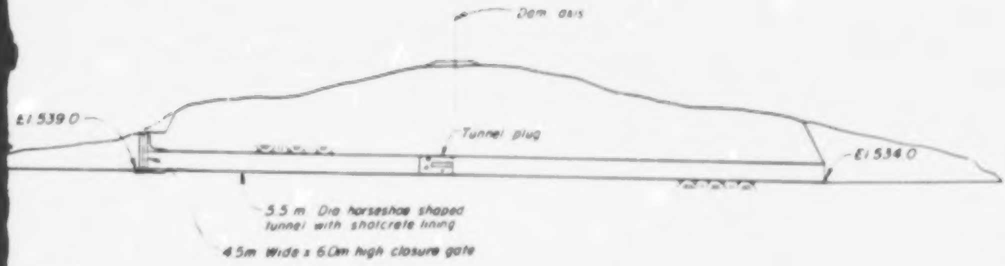
SECTION THROUGH DIVERSION TUNNEL


10.0
pool
El 562.5
3.8
El 570.0
Transition
Riprap
2.25
1
2.5
1
Drain
Slope protection
Filter
2
1
El 543.0
Slope protection
El 538.0
Rockfill
Sand and gravel shell
Sand and gravel shell
Alluvium
Till core
Rockfill
Impervious blanket
Alluvium and boulders
Sheet pile cutoff (if required)
Grout curtain
Assumed bedrock
Blanket grouting
Sheet pile cutoff (if reqd)

SECTION THROUGH EARTHFILL DAM


Approx. ground surface
El 570.0
Assumed rock surface
Diversion tunnel
Assumed core / bedrock contact

DOWNSTREAM ELEVATION


Dam axis
El 539.0
Tunnel plug
El 534.0
5.5 m Dia horseshoe shaped tunnel with shotcrete lining
4.5m Wide x 6.0m high closure gate

Scale 20 0 20 40 60 80 Metres

SECTION THROUGH DIVERSION TUNNEL

All dimensions are in metres, unless otherwise shown

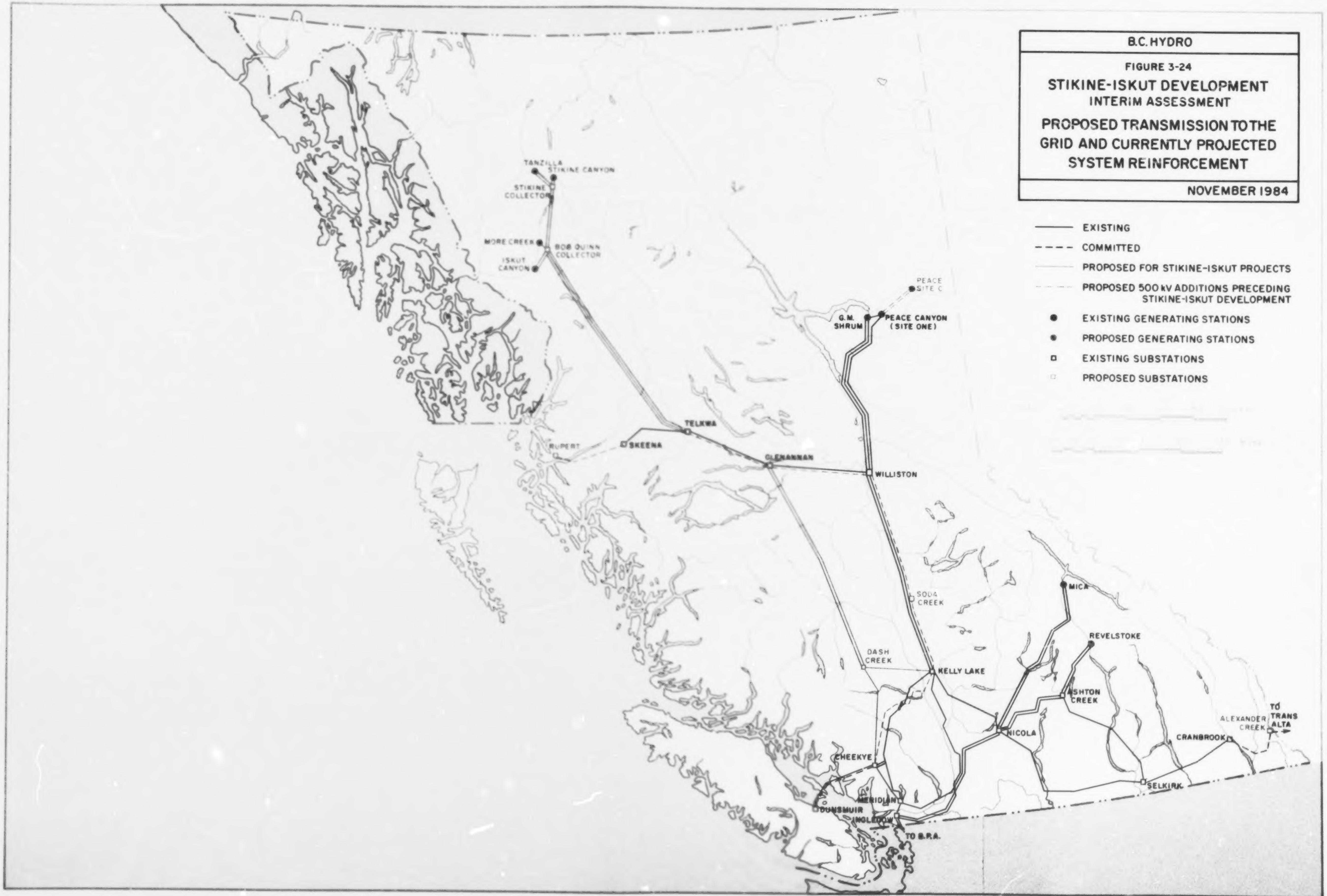
BRITISH COLUMBIA HYDRO AND POWER AUTHORITY

STIKINE - ISKUT DEVELOPMENT - MORE CREEK PROJECT

FORREST KERR CREEK DIVERSION DAM PLAN, ELEVATION & SECTIONS

DATE DEC 1984	FIG. 3 - 23
DWN CY	DWG No 913-C14-C482

REPORT No. H1720


TANZILLA
STIKINE CANYON
STIKINE COLLECTOR
MORE CREEK
BOB QUINN COLLECTOR
ISKUT CANYON
TELKWA
SKEENA
RUPERT
GLENANNAN
WILLISTON
G.M. SHRUM
PEACE CANYON (SITE ONE)
PEACE SITE C
SODA CREEK
DASH CREEK
KELLY LAKE
MICA
REVELSTOKE
ASHTON CREEK
NICOLA
CHEEKYE
MERIDIAN
DUNSMUIR
INGLEDOW
TO B.P.A.
SELKIRK
CRANBROOK
ALEXANDER CREEK
TO TRANS ALTA
EXISTING
COMMITTED
PROPOSED FOR STIKINE-ISKUT PROJECTS
PROPOSED 500 kV ADDITIONS PRECEDING STIKINE-ISKUT DEVELOPMENT
EXISTING GENERATING STATIONS
PROPOSED GENERATING STATIONS
EXISTING SUBSTATIONS
PROPOSED SUBSTATIONS

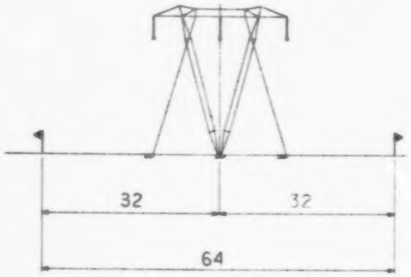
B.C. HYDRO

FIGURE 3-24

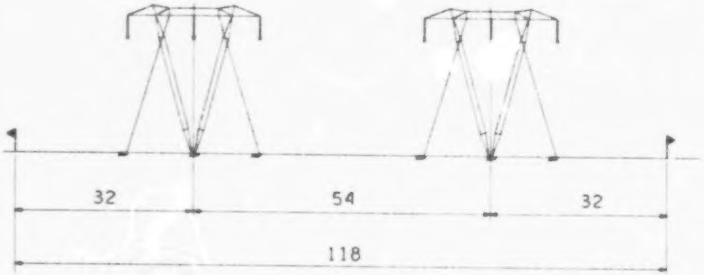
STIKINE-ISKUT DEVELOPMENT
INTERIM ASSESSMENT

PROPOSED TRANSMISSION TO THE GRID AND CURRENTLY PROJECTED SYSTEM REINFORCEMENT

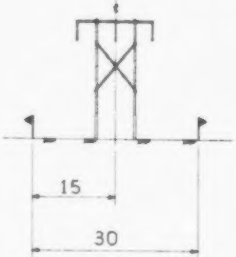
NOVEMBER 1984



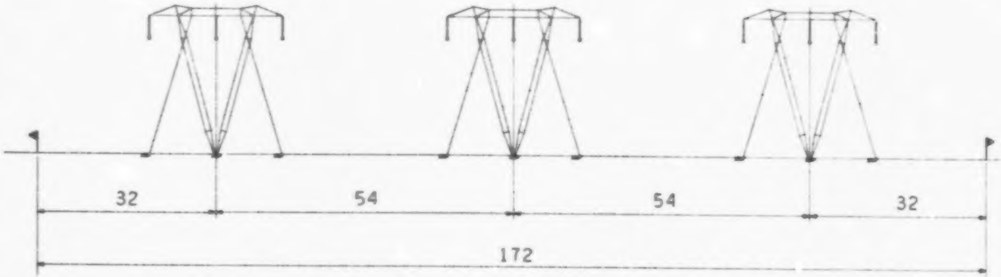
R/W FOR ONE SINGLE CIRCUIT
500 kV TRANSMISSION LINE



R/W FOR TWO SINGLE CIRCUIT
500 kV TRANSMISSION LINES



R/W FOR ONE SINGLE CIRCUIT
230 kV TRANSMISSION LINE



R/W FOR THREE SINGLE CIRCUIT
500 kV TRANSMISSION LINES

NOTES:

1. DIMENSIONS ARE BASED ON PRELIMINARY STRUCTURE DRAWINGS.
2. DIMENSIONS ARE IN METRES.

B.C.HYDRO
FIGURE 3-25
STIKINE-ISKUT DEVELOPMENT
INTERIM ASSESSMENT
TYPICAL RIGHT-OF-WAY WIDTHS
STANDARD SINGLE CIRCUIT
PHASE CONFIGURATION
NOVEMBER, 1984

TABLE 3-1

STIKINE CANYON PROJECT
SUMMARY OF HYDRAULIC DISCHARGE FACILITIES

Auxiliary Spillway:	3 radial gates - 15.0 m wide x 15.0 m high Gate freeboard: 0.6 m Sill elevation: 779.6 m Maximum head : 17.4 m (at PMF) Chute length : 680 m Number of flip buckets: 1 Flip bucket elevation : 625 m Maximum discharge capacity: 6450 m³/s
Service Outlets:	4 jet flow gates: 2 at El. 642 m and 2 at El. 627 m Diameter : 3.0 m Maximum head : 155 m and 170 m Total maximum discharge capacity: 1300 m³/s
Low Level Outlets:	2 jet flow gates: 1 at El. 605 m and 1 and El. 575 m Diameter : 3.0 m Maximum head : 170 m Total maximum discharge capacity: 620 m³/s

TABLE 3-2

TANZILLA PROJECT
SUMMARY OF HYDRAULIC DISCHARGE FACILITIES

Auxiliary Spillway:

3 radial gates - 15.0 m wide x 15.0 m high
Gate freeboard: 0.6 m
Sill elevation: 516.6 m
Maximum head : 17.4 m (at PMF)
Chute lengths : 190 m, 170m and 150 m
Number of flip buckets : 3
Flip bucket elevations : 450 m, 440 m and 430 m
Maximum discharge capacity: 6450 m^3/s

Service Outlets:

3 jet flow gates: 1 at El. 424 m and 2 at El. 402 m
Diameter : 3.0 m
Maximum head : 132 m
Total maximum discharge capacity: 830 m^3/s

Low Level Outlets:

2 jet flow gates: 1 at El. 380 m
Diameter : 2.7 m
Maximum head : 154 m
Total maximum discharge capacity: 500 m^3/s

TABLE 3-3

ISKUT PROJECTS - RESERVOIR OPERATING LEVELS

	Iskut Canyon	More Creek	Forrest Kerr Diversion Dam
Maximum Normal Reservoir Level (m)	347	535	-
Minimum Normal Reservoir Level (m)	312	493	-
Drawdown (m)	35	42	-
Maximum Flood Level (m)	350	538	562.5
Dead Storage million m^3	400	700	-
Power storage million m^3	900	1500	-

SECTION 4.0 - DEVELOPMENT COSTS AND BENEFITS

4.1 PROJECT CAPITAL COSTS

4.1.1 CAPITAL COST ESTIMATE

The following table summarizes the $6 billion capital cost estimate for the generation and transmission projects, amounts being stated in millions of 1984 dollars. Overhead has been assumed at 9% of direct costs for the purpose of this report.

	1984 $ Millions Direct Costs	Overhead	Total
Generation:			
Stikine Canyon	1997	180	2177
Tanzilla	1170	105	1275
Iskut Canyon	1174	106	1280
More Creek	418	38	456
Total Generation	4759	429	5188
Transmission	673	60	733
TOTAL DEVELOPMENT	5432	489	5921

The above estimate covers all expenditures necessary to carry out the final design and construction of the generation facilities and of the transmission facilities (including substations) required to receive the energy generated into the existing system at Telkwa substation.

However, introduction of Stikine-Iskut energy into the existing system means that the system would require reinforcement and the estimated additional transmission and substation costs for this are:

	1984 $ Millions Direct Costs	Overhead	Total
System Reinforcement	339	30	369
Total Development plus Reinforcement	5771	519	6290

Chapter 7 describes two partial development alternatives i.e., the two Stikine river projects alone, or the two Iskut projects alone. The cost of each alternative pair of generation project would be independent of whether and when the other pair is developed. However transmission requirements would differ as described in Chapter 7. Applicable cost estimates including overhead are:

	Generation	Transmission	Reinforcement	Total
Stikine Canyon & Tanzilla alone	3452	563	265	4280
Iskut Canyon & More Creek alone	1736	391	-	2127

4.1.2 RELIABILITY OF CAPITAL COST ESTIMATES

Before any development alternative can be approved for construction, it will be necessary to estimate and justify the total projected outlay of funds, including inflation effects and financing charges. These estimates must consider uncertainties of interest and inflation rates and potential schedule delays. The capital costs presented in this chapter do not address these uncertainties, since they are presented in constant dollars.

Nevertheless, the uncertainties present in these project estimates are substantial in their potential effects on cost. Examples under the two main categories of uncertainty are:

Design Uncertainties

- Layout of generation projects and associated variables such as dimensioning of structures and equipment, sizes and treatment of excavation necessary to ensure stability; quality and availability of suitable gravel and rock for embankment and concrete structures, or length and configuration of water passages.
- Route selection, number and capacity of lines, or design standards for towers and conductors for the transmission project.

Price Uncertainties

(These are in addition to the changes in estimate resulting directly from a change in design scope)

- Premium for northern construction and related productivity as affected by availability of labour, the extent of overtime hours needed and turnover costs.
- Tender prices as affected by market conditions which could be in "boom" or recession.

4.1.3 CONTINGENCIES

Contingency allowances are included in both the generation and transmission estimates to account for uncertainties such as the above.

a) Basis of Generation Contingency Allowance

B.C. Hydro has experience of past generation projects which included features comparable to almost all aspects of the Stikine-Iskut projects. Tender unit prices and some actual construction costs experienced by contractors provide a good basis for estimating the

Stikine-Iskut projects. Nevertheless major uncertainties exist as stated above. These have been accounted for in the estimates as follows:

i) Design

Hydro does not have direct experience of high arch dams nor of concrete dams of any type as high as that proposed for Stikine Canyon. However, a conservative design has been assumed and the arch design and greater height should not greatly increase the difficulty of construction compared to past designs.

The basis of the cost estimates is described more fully in each Engineering Preliminary Design Report (No. H1718 for the Stikine Projects and No. H1674 for the Iskut Projects). During Preliminary Design to date, the major concerns facing design of all project features have been reviewed. Analysis of design uncertainty shows that although there are opportunities for design changes to cause increases in estimates in the future the current assumptions are generally pessimistic, particularly with regard to the boundaries of the excavations and the structural requirements of the dams. Therefore only a 6% contingency, has been assumed for design changes. An estimated 3% has also been assumed for increases due to detailing of the design.

In the past the major design changes occurring during the construction phase have been as a result of improved information following dewatering of the dam foundation after river diversion, and during excavation for major structures. This has been addressed partly by the investigation of the rock and partly by analysis of exposure to uncertainty as described above.

ii) Price

The Development is more isolated than any previous Hydro project. However, the Peace River and Mica projects were each relatively isolated (accentuated during the early years of construction by low standards of access roads).

During Preliminary Design to date review of the major pricing concerns facing all constituents of the estimate was carried out. Analysis of pricing shows that there are significant uncertainties of construction costs, many of which will remain until market conditions during the Stikine-Iskut construction period are known. The most important aspects of market conditions are their effects on availability of labour and on tender prices quoted for major contracts. Current estimates are based on pessimistic pricing assumptions so that there is opportunity for decreases as well as for increases. Nevertheless allowances must be made for additional costs of acceleration and contractors' claims as well as for some upward movement due to market conditions; 6% contingency is estimated for these.

iii) Total

The total contingency is therefore 15% which is applied for direct costs of all civil items. Mechanical and Electrical items are less exposed to design changes and are less labour intensive; 10% is therefore applied to them. These estimates of contingency are included within the stated cost estimates for the projects; they are not an upper limit of cost. To obtain an upper limit it would be necessary to add a further 15% to 20% to the total cost estimate.

b) Basis of Transmission Contingency Allowance

Cost estimates for the Stikine-Iskut transmission project listed above are based on the use of single circuit steel tower construction, with each of the three phases in the same horizontal place (i.e. "flat" configuration), and Mica-type conductor.

The route segments have been evaluated from an access, clearing and design point of view. The quantities of materials and labour required for each segment of the line were developed using actual experience from similar existing line segments within the B.C. Hydro system. Historic unit costs, based on recent contract prices for materials and labour and adjusted for the remoteness of the area, were then applied to these quantities. Obvious special requirements such as major river crossings for special foundations were identified and estimated.

Uncertainties set out above have been accounted for in the estimate as follows:

i) Design

At this stage the preliminary route location has been developed using air photographs and topographic maps, supplemented by aerial reconnaissance. Actual centreline survey and other detailed site investigations have not yet been carried out and would be necessary to remove some of the uncertainties associated with the transmission line design.

For the transmission project as described, the primary design uncertainties are:

Length of Route

Variations in the route within the corridors selected for further study should not significantly change the overall route lengths. The maximum variation in route length should not exceed ±2 to 3%, since the cost estimates are directly proportioned to these lengths, the change in the cost estimates should be in the range of ±2 to 3%.

Tower & Conductor

The cost estimates were prepared based on the use of Mica type towers and conductors. Research in co-operation with international organizations on new types of towers is currently at a preliminary stage. For example the use of a "cross-rope suspension" type of tower, together with larger conductor in an inverted delta configuration on the Bob Quinn to Telkwa segment would increase the total cost estimate for the preferred routes by about 8%. However, this change would not be made unless it would improve line efficiency sufficiently for the operating benefit to exceed the construction cost. Therefore, no allowance is included for this design change possibility.

Design Parameters and Foundation Conditions

The access, clearing and design characteristics can be quite different from those assumed for the cost estimates. In addition the foundation conditions are site specific. Some towers will require pile foundations while others may require special design if permafrost conditions are encountered.

It is estimated that costs could change by as much as ±5 to 6% due to variations in design parameters and foundation conditions compared to that assumed in the cost estimates.

ii) Price

As the prices used in the capital cost estimates are based on historic costs, actual project costs would differ from estimates if construction period economic conditions, including applicable northern premium, are different. An adjustment must also be made for the possibility of contractors' claims. A review of these possibilities has resulted in an estimated change in costs ranging from -5% to +15%.

iii) Total

The total range of estimated design and price uncertainty for the transmission project would therefore be -14% to +24%. The standard contingency allowance of +15% for transmission project cost estimates at this stage of development appears reasonable and has been included in the Stikine-Iskut transmission project cost estimates.

4.2 BENEFITS

Two benefits would result from the construction of the Stikine-Iskut Development: First, additional electric energy would be produced to meet demand throughout the year and second, additional generating capacity would be available to meet peak loads.

The average energy that the Stikine-Iskut development could produce each year is considered to be the average of that which could be attained during a repetition of the forty year reference streamflow record for the Stikine and Iskut river basins from 1940/41 to 1979/80. This energy would consist of both firm energy and secondary energy. Firm energy is the average energy that could be assured from the hydroelectric system as a whole during a recurrence of a drought coincident throughout the B.C. Hydro system, corresponding to the historic streamflow period from October 1940 to April 1946. The average annual firm energy with seasonal load shaping that could be sustained by the development during a recurrence of these critical streamflows can be computed by dividing total firm energy which could be produced during this 67 month drought period by 5.61. This factor is equal to the ratio of the total energy load over the entire critical period to the total energy load in one year.

Secondary energy is equal to the difference between average energy and firm energy.

Calculations of the energy available from the Stikine-Iskut Development are based on simulations of the difference in capability of the total Hydro system operating with and without the proposed development.

The Hydro system is expected to have sufficient generating capacity to meet peak demand until after 2025. Accordingly the additional capacity provided by the Stikine-Iskut Development would be of no benefit to the system as a whole until then.

4.3 COMPARATIVE ASSESSMENT OF DEVELOPMENT

4.3.1 GENERAL

The following two assessments compare the attractiveness of the Stikine-Iskut development with other generation alternatives available to B.C. Hydro. In the first assessment the benefits of the Stikine-Iskut Development, i.e. firm energy, secondary energy and capacity are valued. The total value of the benefits divided by the costs gives a measure of the development's economic merit. While this ratio is a useful indicator it should not be considered to be the benefit-cost ratio for the development. The values used for the benefits of the development are based on the costs of providing energy and are therefore only indicative of the true value. Also at this stage in the studies, while construction costs are well developed, social and environmental estimates require more consideration cost.

In the second assessment the unit cost of energy produced by the development is calculated and this cost is compared with equivalent unit energy costs from other possible developments.

4.3.2 VALUATION OF BENEFITS

In the valuation of benefits, four alternative system plan sequences for the construction of potential developments are considered. The timing of projects in each sequence is adjusted in the light of the probable low, the probable and the probable high forecasts. For each of the sequences and forecasts a single value for firm capacity and energy is calculated based on the time weighted average cost of firm power and energy of each of the projects that formed the sequence. These 12 values were then averaged to produce an overall estimate of the value of firm capacity and energy. Because of the complexity of this calculation and the fact that it relies on uniform cost data from the number of potential projects it is carried out on an annual basis. The most recent results, based on 1983 costs, determined that the value of combined firm capacity and firm energy was 24.6 mills/kW.H. Calculations of the value of firm capacity today based on the future cost of providing this at Mica or Revelstoke or ultimately through a pumped storage hydro project in the lower mainland show that this is worth 1.0 mill/kW.H. This leaves the value of firm energy at 23.6 mills/kW.H. Studies of the potential uses of secondary energy on the B.C. Hydro system have indicated that its value would be 50% of the value of firm energy i.e. 11.8 mills/kWH.

Multiplying these values by the energy and capacity available from the Stikine-Iskut Development gives the overall benefit from the development. Dividing the benefit by the cost of the development gives a measure of the development's attractiveness. Using 1983 development costs for consistency with the benefit calculations a figure of 1.14 is obtained. This figure indicates that the cost of the Stikine-Iskut Development is significantly more attractive than the average cost of those projects being considered as a potential source of energy.

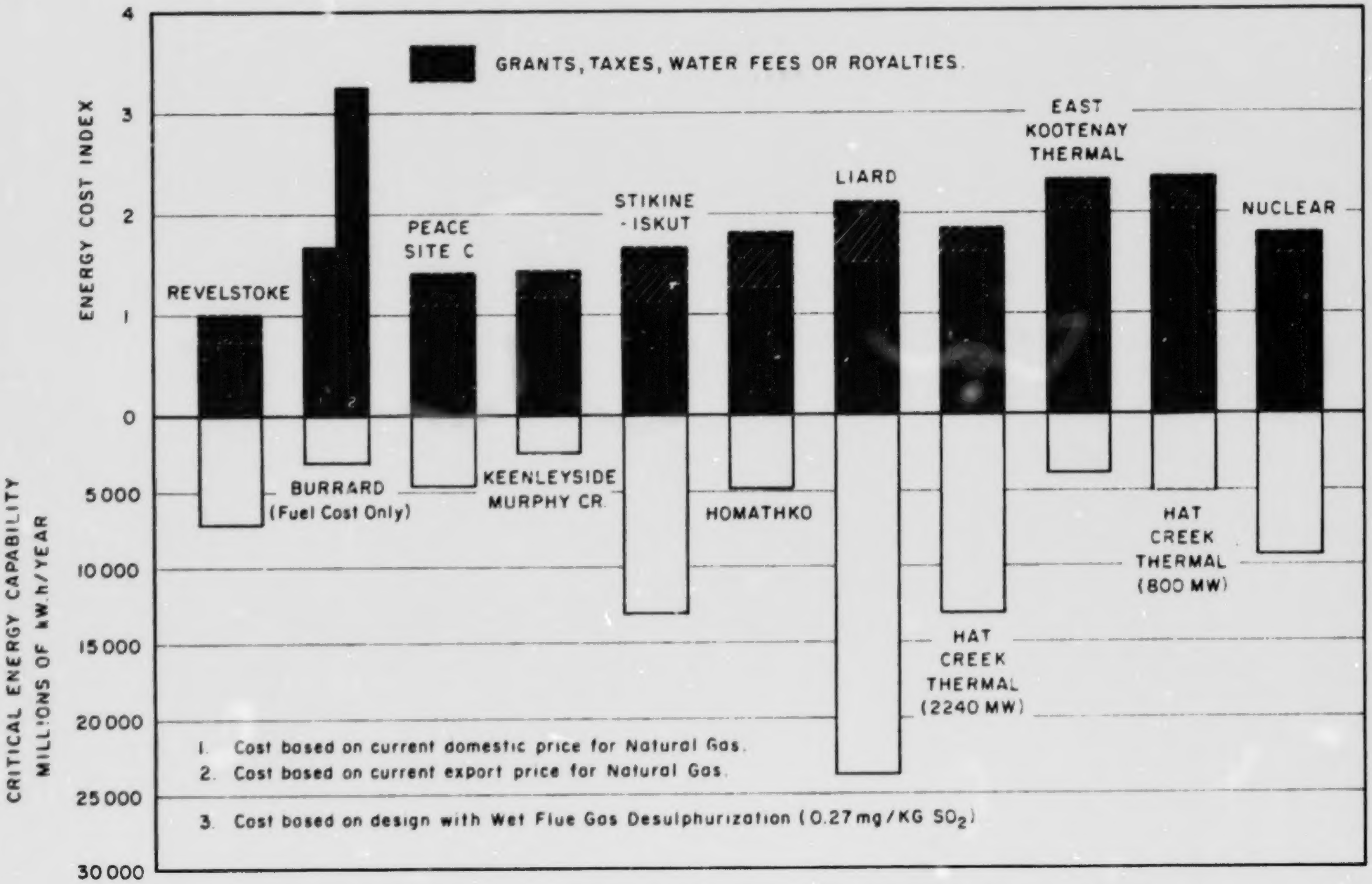
4.3.3 UNIT ENERGY COSTS

Table 4.1 shows the unit energy costs of the Stikine-Iskut Development together with the unit energy costs of other projects which were considered in the system plan sequences to be potential sources of energy. This table indicates that the Stikine-Iskut is the most economic development after Peace Site C.

Fig. 4.1 provides a graphic comparison of the projects. It should be noted that the advanced level of the Stikine-Iskut studies means that the costs given can be treated with a greater degree of confidence than those given for projects at an earlier level of study. Reference should also be made to Chapter 7 which discusses the implications of developing only part of the scheme or of splitting it into a number of parts to reduce the financial commitment required at any one time.

FIGURE 4-1

COMPARISON OF LONG-TERM ENERGY COSTS AND CRITICAL ENERGY CAPABILITIES FOR EXISTING AND POTENTIAL PROJECTS



1. Cost based on current domestic price for Natural Gas.
2. Cost based on current export price for Natural Gas.

3. Cost based on design with Wet Flue Gas Desulphurization (0.27 mg/KG SO_2)

NOTE: All energy costs are compared with energy costs (including taxes) for the Revelstoke Project (i.e. Revelstoke including taxes has an energy cost index of 1.0).

MAY 1984

TABLE 4-1

PROJECT COSTS

	Discount Rate Net of Inflation						
Project	3%	4%	5%	6%	8%	10%	12%
Unit Energy Costs*1							
(October 1983 mills/kW.H)							
Excluding Taxes							
Peace Site C	15.0	18.4	22.2	26.3	35.3	45.2	55.9
Murphy/Keenleyside	15.9	19.7	23.8	28.4	38.3	49.4	61.5
Stikine-Iskut	15.5	19.1	23.1	27.5	37.3	48.2	60.2
Liard (Devils Gorge/ High Beavercrow)	20.7	25.6	31.3	37.5	51.8	68.6	88.0
Homathko	17.2	21.1	25.3	29.8	39.6	50.1	61.3
Elaho	17.2	21.3	25.7	30.5	40.9	55.3	70.3
Border*2	16.5	20.6	25.3	30.4	42.0	55.3	70.3
Hat Creek 800	30.7	34.5	38.8	43.4	53.8	65.6	78.6
Including Taxes							
Peace Site C*1	20.4	23.8	27.7	31.8	40.7	50.6	61.4
Murphy/Keenleyside	20.7	24.4	28.5	33.0	43.0	54.0	66.2
Stikine-Iskut	24.6	28.3	32.3	36.7	46.5	57.5	69.6
Liard (Devils Gorge/ High Beavercrow)	30.9	35.9	41.5	47.8	62.2	79.1	98.6
Kootenay Diversion*1	16.8	19.2	21.9	24.7	30.9	37.4	44.3
Homathko	26.8	30.7	34.9	39.4	49.2	59.7	70.9
Elaho	26.8	30.9	35.3	40.1	50.5	62.0	74.4
Border*1	21.0	25.2	29.8	34.9	46.5	59.8	74.8

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*1 These Columbia and Peace River projects are exempted from school taxation.

*2 Estimated costs for Border are preliminary.

SECTION 5.0 - ENVIRONMENTAL AND SOCIO-ECONOMIC ASSESSMENT

5.1 GENERAL

5.1.1 Introduction

Overview engineering and environmental studies conducted in 1977 concluded that, based on preliminary data, the Stikine-Iskut development was technically feasible and economically attractive. Subsequently, studies were authorized to obtain the additional engineering and environmental information required to evaluate the impacts of the proposed development in detail. Detailed environmental studies for the generation component of the development were initiated in 1978 and have continued at varying levels of intensity until the present.

Preliminary level transmission environmental studies began in 1978 and ended in 1982 with the publication of the Preliminary Planning Report. Detailed transmission environmental studies slated to commence in 1983 did not proceed much beyond consultant selection in most discipline areas as a result of the deferral of the development. Additional study for the transmission environmental studies, including some fieldwork, was conducted for this Interim Assessment Report (IAR).

5.1.2 Overall Impact Assessment Objectives and Scope of Environmental Studies

Over the 5 to 6 years that environmental studies have been in progress on the Stikine-Iskut development, environmental impact assessment methods have evolved along with the changes in the environmental regulatory review process in British Columbia. Much of the evolution concerning B.C. Hydro's environmental studies for this development increased detail or area of coverage but did not alter substantially the approach to the work. In 1978, when detailed terms of reference for the generation environmental studies were developed, the Energy Projects Review Process (MOE, 1982) was in formulative stages and Guidelines for Linear Development (ELUC, 1977) and Guidelines for Benefit-Cost Analysis (ELUC, 1978) were just emerging. Interpretations of the requirements of the new guidelines were plentiful but uncertainties as to levels of detail required in these studies were being reduced. Although developed in this evolutionary period, the environmental impact assessment objectives for work on the Stikine-Iskut development have been from the outset to:

1. provide an inventory of environmental resources that could be impacted by the development;

2. evaluate qualitatively or where possible quantitatively the benefits and costs of these expected impacts; and

3. determine what mitigation and compensation measures are appropriate to minimize the impacts of the development on environmental and socio-economic resources.

The following considerations have helped determine the scope and type of study to be undertaken in the inventory stage.

1. The study must help in the quantitative or qualitative prediction of impacts.

    a. The study should determine or help to determine a "cause - effect" relationship; what are the physical changes being made to the habitat and what is the biological response.

    b. Baseline (or monitoring) studies will provide a yardstick which can be used to detect environmental impacts after the development is in place. However, baseline studies alone will not allow prediction of impacts. Furthermore, for baseline studies to be useful, natural and man-induced variability must be known prior to any post development impact identification. Evaluation of variability is often difficult and expensive.

2. The study must be cost-effective.

   a. B.C. Hydro expenditures on development studies are subject to scrutiny by the B.C. Utilities Commission. It is B.C. Hydro's responsibility to demonstrate that environmental studies undertaken are useful in aiding a decision of whether or not to build the proposed development.

   b. Expenditures on studies must be influenced by the usefulness of the results. Studies of provincially significant resources which may be impacted to a major extent are given priority.

   c. When the cost of predicting impacts precisely is very high it may be more efficient to determine impacts in a general way and to reserve money for mitigation or compensation.

5.1.3 Overall Environmental Study Methodologies

(a) Generation

A common methodological framework for environmental impact assessment was applied to studies conducted for the generation component. This standardization was important to provide information suitable for inclusion in the benefit/cost analysis and identification of mitigation and compensation alternatives. The framework required identification of the following:

1. The local, regional and provincial significance of the resource (with and without the project) based on:

    a. present value; and
    b. potential value.

2. Beneficial and adverse primary, secondary and induced impacts.

3. The distributional aspects of impacts:

    a. Geographical - local, regional, provincial, national and international.

    b. Social - impacts on various segments of the population, including ethnic or special interest groups.

    c. Transfer of resource benefits and costs to other locations.

4. The probability of the occurrence and extent of an impact or reasons for uncertainty of the same.

5. Expected time and duration of an impact occurrence.

6. The benefits, both short- and long-term, of any possible enhancement and mitigation measures.

7. The costs associated with enhancement and mitigation alternatives in terms of:

    a. constraints on the proposed project description due to a mitigation program to be undertaken (e.g. water level adjustments on Stikine Canyon reservoir to avoid interference with seasonal caribou river crossings); and

    b. the actual cost of the mitigation program itself.

8. The relationship between project impacts and long-term regional development prospects.

(b) Transmission

Hydroelectric generation sites have specific engineering requirements which limit their possible location. Transmission lines also have specific design requirements, but offer greater flexibility in terms of location. In many cases, environmental concerns can be alleviated by careful corridor, route and right-of-way selection. Consequently, the major emphasis of environmental studies for the transmission component was the provision of data to assist with routing the line. Once a route was identified, a detailed impact assessment would be possible.

In the case of the Stikine-Iskut development, the preliminary data collected between 1978 and 1982 was used to assist in the selection of a preferred corridor. Within this corridor a preliminary route was chosen. Detailed environmental studies were aimed at analyzing this route in an iterative process to further define it. Once it was established, an impact assessment, resource evaluation and mitigation plan were to be completed. The methodologies for these detailed assessments were to be similar to those required for the generation component. Although terms of reference were prepared for the detailed studies, the work was not undertaken because of the deferral of the development studies.

5.1.4 Objectives and Scope of the Interim Environmental Assessment

From an environmental perspective, the Interim Assessment Report has four major objectives.

1. To evaluate environmental and socio-economic data and interpretations produced since the overview stage (1977) to determine whether

or not the Stikine-Iskut development remains technically feasible and economically attractive.

2. To identify and summarize all studies carried out to date.

3. To determine needs for additional work to achieve a defensible environmental and socio-economic impact assessment and development design.

4. To integrate into one document the environmental and socio-economic effects of transmission, generation, downstream and off-site components of the development which have not previously been brought together.

For discussion purposes, the development area has been divided into three local areas (Fig. 5-1). Area 1 (downstream) environmental impacts result primarily from project alteration of water quality or quantity, although some socio-economic impacts may also result in this area from other development-related activities.

Area 2 (generation area) contains the generation projects and a portion of the transmission network. In this area, it is not always possible to partition environmental impacts between transmission and generation projects.

Area 3 (transmission line area) consists of the transmission line corridor south of the Bob Quinn Collector station. Here the biophysical impacts and most of the socio-economic impacts are attributable to transmission line construction.

Regional study areas are normally larger than any of the defined local study areas but smaller than the province. They are defined differently for each discipline area and often reflect management or harvest boundaries. Environmental impacts in this report are discussed primarily on the basis of a combination of the extent (site-specific, local, regional, etc.) and duration (construction, short-term, long-term, etc.) of their effects.

5.2 SPECIFIC ENVIRONMENTAL STUDIES

5.2.1 Climate and Air Quality

(a) Studies Completed and Planned

Historically, the Stikine-Iskut basin has had less meteorological station coverage than any comparably sized area in Canada. A climatological station was established at Telegraph Creek in July 1942 and twice daily readings of maximum and minimum temperatures and percipitation were recorded. However, the station was moved a number of times, resulting in approximately 11 years of missing data since its installation. Other Atmospheric Environment Service (AES) climatological stations were established at Todagin Ranch in September 1973, Iskut Ranch in July 1976 and Bob Quinn Lake in December 1977. These stations are still active, while another station operated briefly at McBride River from June 1975 to April 1978. Their locations are shown on Fig. 5-2.

Many other meteorological parameters which are important in hydrological, biological, wildlife and other environmental studies have not been documented in the Stikine-Iskut basin. These include humidity, cloud cover, visibility, sunshine, solar radiation and evaporation. A number of these have been recorded at Dease Lake Airport since September 1944, but the site is outside the Stikine-Iskut basin and the data are only applicable to the immediately adjacent portion of the basin.

In order to quantify the available water for storage in the Stikine-Iskut basin, B.C. Hydro, with the assistance of the Waste Management Branch (WMB) of the B.C. Ministry of Environment, established a climatological station network to measure precipitation, temperature, and, in selected areas, wind data.

Seventeen stations were installed in the summer of 1979, with four additional stations placed in 1981. A typical station included a thermograph mounted in a Stevenson screen along with maximum and minimum thermometers for calibration, a recording precipitation gauge, two PVC storage gauges for checking accumulated rainfall and a snow stake for checking accumulated snowfall. Stations were distributed within the basin on the average of one station per 450 km^2, at elevations ranging from 20 m above MSL to 1525 m. The locations of these stations are shown on Fig. 5-2.

Standard snow courses were located in the vicinity of nine of the stations in 1979. To assess the wind flow over the basin, three anemometers on 10-m towers were sited in 1979, and three additional in 1981. (See Fig. 5-2).

(b) Existing Climate

(i) Regional Climate and its Geographic Controls

The climate of the Stikine and Iskut river basins is dominated by their proximity to the Pacific Ocean on the west, and to the source regions of Continental Arctic air to the north and east. The massive barrier of the Coast Mountains, with peaks over 3000 m, limits the incursion of moist, mild Pacific airmasses which are forced to release much of their moisture on the windward slopes of these mountains over the lower reaches of the Stikine and Iskut rivers. Successive mountain ridges east of the Coast Mountains each further reduce the moisture content of Pacific air as it pushes into the upper reaches of the Stikine and Iskut basins.

On a seasonal basis, maximum precipitation occurs through the Coast Mountains area in fall and winter due to the frequent development of Pacific storms. East of the Coast Mountains, maximum precipitation occurs in the summer months when extended solar radiation promotes the development of daytime convective clouds.

The buildup of Arctic high pressure areas over northwestern Canada in winter results in the penetration of cold, dry Arctic air through valleys in the Cassiar Mountains into the Stikine and Iskut valleys. Drainage of cold air into the valley bottoms allows winter overnight minimum temperatures in these areas to frequently reach the -40° to -45°C range under cloudless skies. In these situations, temperatures on the higher slopes remain 5° to 15° warmer, resulting in semi-permanent valley inversions. The outbreaks of Arctic air occasionally reach the Pacific Ocean, but normally in winter there is a strong temperature transition in the valleys of the Coast Mountains.

In other seasons, daytime temperatures are relatively uniform over the basins, with warmer temperatures in the valleys and cooler temperatures aloft. Valley inversions develop overnight east of the Coast Mountains, while in the lower reaches of the Stikine and Iskut rivers, increased cloud cover reduces outgoing radiation.

(ii) Climate Data Summary

Climate in the Stikine-Iskut area is extremely variable. It would take a very large number of fully instrumented stations to document the range of variation in the basin. In addition, there are data uncertainties because of the inability of instruments to record information which are representative of a large area. These considerations are included in the discussion below of the data obtained.

A. Total Precipitation

Data on total precipitation (rain plus melted snow) is tabled as a monthly mean and annual mean for selected stations in Table 5-1. The table also includes the number of months of record for each month of the year. These data do not take into account a possible undercatch of snow by the recording instrument. An analysis suggests that as much as 23 percent of snow may be "missing" from the measurements. Instrument malfunction resulted in the loss of 8 percent of the potentially available information.

Comparisons of data for adjacent pairs of stations with differences of elevation indicate that elevation enhancement of rainfall in summer (June to August) averages 0.3 mm/month, and snowfall (water equivalent) in winter (November to February) averages 0.5 mm/month east of the Coast Mountains.

Mean annual precipitation amounts for the region have been plotted on Fig. 5-2. Mean annual precipitation amounts range from 308.7 mm at Klappan to 1726 mm at Lower Iskut. Not shown is the very large variability that can occur in the same months total in successive years, e.g. 91 mm of rain in June 1981 and 0.9 mm in June 1982 at McBride 5000. This emphasizes the need for many years of data before reliable climatic normals can be developed.

B. Temperature

The mean monthly maximum and mean monthly minimum temperatures, and the monthly extremes of these, for the 21 network stations, the five long-term AES Climatological Stations (Environment Canada 1951-80), and longer-term data from McBride River have been summarized and are shown in Table 5-2. Data recovery was 94 percent on the basis of data being valid provided two-thirds of the daily information was available.

During winter, mildest temperatures occur within the Coast Mountains, with very little temperature gradient, either horizontally or vertically, as modified Arctic air in the valleys is overrun by maritime Pacific air. East of the Coast Mountains cold, dry Arctic air sinks to the valley bottoms with milder air over higher ground, producing a semi-permanent valley inversion.

In July the mean maximum temperatures are in the valley bottoms, both in the lower and upper Stikine and Iskut. East of the Coast Mountains the lapse rate (decrease of temperature with height) indicates that afternoon convective clouds can develop readily, provided there is enough moisture in the air. Over the lower Stikine and Iskut, the lapse rate is considerably less.

Mean minimum temperatures in July have very little horizontal gradient over the Stikine and Iskut basins. Overnight valley inversions do occur on clear nights, but in general, the lapse rates are near isothermal. Dawson

Climatological Station shows a fairly strong inversion, but it is local in nature and not representative of the valley as a whole.

C. Wind

There are six anemometers in the Stikine-Iskut river basins, five in valley bottoms and one on an upper plateau. The brief period of record from the instruments indicates that valley orientation dominates wind direction for those in the valley bottoms, with a light to moderate down-valley flow of Arctic air in the colder months and a light up-valley flow of Pacific air in other seasons. The higher elevation site documents quite strong winds in all months, with a northeast through southeast circulation in the colder months and south through west flow at other times.

(c) Impact Assessment

Theoretically, the formation of a reservoir can result in the modification of a number of meteorological parameters.

1. The presence of a large, deep waterbody can act as a heat sink in summer and a heat source in winter with the consequent effect of modifying air temperatures over and near the reservoir.

2. If the reservoir is large, the decreased surface roughness of the water compared to land will allow surface wind speeds to increase over the reservoir, if the air is unstable.

3. If the reservoir is not ice covered and the air is sufficiently moist, evaporation from the reservoir may allow fog to

form provided the air is not unstable, the wind is not too strong and skies are clear enough to allow radiative cooling.

4. If the reservoir is large enough and the air is moist and unstable, evaporated moisture from the reservoir could enhance the formation of convective cloud cover and possibly result in an increase of precipitation downwind of the reservoir.

Impact assessment is based on studies carried out on the Williston reservoir on the Peace River (Schaefer, 1976) and takes into account the very much smaller sizes of the Stikine/Tanzilla and Iskut/More Creek reservoirs (12 and 21 times respectively). Although some slight modifications were noted in the Williston study these would be even more difficult to document for the smaller reservoirs of the Stikine/Iskut project. Given the large day to day and year to year variability in measured climatic parameters any small fluctuation due to the project would most probably be unmeasurable. Overall the following potential modifications may occur.

(i) Temperature

The effect of a large, deep reservoir during spring and summer, would be to reduce the mean air temperature over and along the reservoir, and to increase it in winter. With the relatively small Stikine-Iskut reservoirs this will amount to less than 1°C change. In spring, summer and fall, daily minimum air temperatures will be lower than water temperatures, hence, air temperature minimums will be raised slightly so that over any potential agricultural land immediately adjacent to the reservoir shorelines the current very short frost-free growing season will be increased by a day or two in some years.

(ii) Clouds and Precipitation

In spring and summer, the normal growth of convective clouds is inhibited when air over a reservoir is cooled from below. Since, in mountainous country, convective clouds normally form over the ridges rather than mid-valley, this process would have no effect on the cloud cover in the vicinity of these small reservoirs in spring and summer. In the fall, and in portions of the winter when the reservoirs are ice-free, the air over the reservoirs would be heated from below, promoting vertical transport of evaporated moisture. However, the major valleys contain strong semi-permanent inversions which inhibit vertical motions so the warming effect of the reservoirs would only erode the bottom of the inversions. If the Arctic air contains enough moisture, the additional amount may be sufficient to produce some low, thin stratus cloud. However, since turbulent rivers produce more spray, which evaporates readily, than still reservoirs, the net increase of moisture to produce cloud would probably be similar over the reservoirs to that currently over the rivers. Based on comparison with Williston reservoir the increase in precipitation from the reservoir would be negligible.

(iii) Wind

Wind speeds in the area of the reservoirs would be affected by the reduced frictional drag of the water surface compared with the "rough" land surface, any changes in atmospheric stability, the length of the fetch over water and the initial wind speed. The reduced drag of the reservoirs would tend to increase speeds. Changes in wind speed due to atmospheric stability would depend on whether the reservoir acted as a heat source or sink and on the presence of an inversion. Since the reservoirs would be contained in narrow, twisting valleys the fetch length would be limited. However, the topography also causes winds to funnel through the narrows resulting in increased wind speeds whether the reservoir is present or not; this is probably a more important factor than the over water effects mentioned above.

(iv) Fog

Fog can form if the air is cooled enough that the amount of moisture present is sufficient to saturate it, provided the air is not unstable and winds are not too strong. In the summer months relative humidities are very low in the daytime. At night, humidities are higher but a reservoir would heat the air from below, resulting in instability. As a result, it is likely that fog would be no more frequent in this season than it is over the rivers at present. In the fall, and in winter months before ice formation, steam fog and ice fog could form over the reservoirs. However, steam fog is thin and would not significantly impair visibility or light penetration. In addition, elevated winter water temperatures are not expected to increase the incidence of downstream fogging. Considering the ways in which fog could form both in the warm and cold seasons, it is probable that there is currently a very large year to year variability in its occurrence and any increase in frequency after reservoir formation would be indistinguishable in this natural variability.

(d) Conclusions

A start to data collection to characterize the climate of the Stikine/Iskut region has been made with the establishment of 21 climate stations, nine snowcourses and six wind flow stations. Based on the limited data collected to date and studies on other reservoirs, it is unlikely that either the Stikine/Tanzilla or

Iskut/More Creek reservoirs would cause any measurable change to the local or regional climate.

5.2.2 Terrain and Geological Resources

(a) Summary of Studies

(i) Generation Area Studies

From an environmental perspective, geological studies for the generation component began with work on compilation of an economic geology report by B.C. Hydro's System Engineering Division (B.C. Hydro, 1980; Report No. SE 8005). Several on-site geological and geotechnical engineering investigations were undertaken concurrently with and subsequent to the economic geology study.

Assessment of slope stability around the proposed reservoirs and detailed terrain mapping and stability evaluation of the Stikine Canyon and Tanzilla reservoir areas were conducted by Klohn Leonoff Consultants over a period from 1980 to 1983 (Klohn Leonoff, 1980, 1982, 1983). In addition, Geotex Consultants Ltd. (Geotex Consultants Ltd., 1983) along with Edward W. Grove (Grove, 1984) and B.C. Hydro's Geotechnical Department (B.C. Hydro, not dated) conducted studies which included an inventory of volcanism, seismicity, fault systems and hot spring occurrence within the study area. This information was part of that required for establishment of reservoir design standards and a volcanic risk assessment which included the determination of the probability and significance of possible reservoir induced or other seismic occurrences.

In 1982, B.C. Hydro provided funding for two mapping projects designed to compile an inventory of soils, surficial geology and landforms in the region including the reservoir areas. One of these, a 1:250 000 scale biophysical mapping project, was initiated by the Ministry of Environment. This program produced terrain features, materials and hazards maps as well as vegetative cover, soils and ungulate biophysical maps, and reports (B.C. Ministry of Environment, 1982). These were produced for NTS map sheets 104F, G, H (North 1/3), B (North 1/2) and ungulate maps included sheet J. A revised terrain inventory report for these areas was subsequently produced (Ryder, 1984).

At the same time, Pedology Consultants were retained to undertake a more detailed (1:50 000) scale soils and surficial geology mapping program of the project-specific study area (Pedology Consultants, 1983). This included areas potentially influenced by the development in the valleys and adjacent plateaus along the Stikine River from the Chutine River confluence upstream to Sullivan Creek as well as the lower valleys of the Klappan River and McBride Creek. The valleys of More Creek, Forrest Kerr Creek, Ningunsaw River and the main Iskut Valley upstream from Iskut Canyon to Burrage Creek were also mapped. Map themes included terrain, soils, terrain hazards and sensitive areas; unique or special landforms; and terrain stability and sensitivity of proposed reservoirs. Detailed mapping (1:10 000 scale) of soils considered to have agricultural capability within the Stikine Canyon impoundment near Highway 37 was also completed as part of Pedology Consultants' program.

A preliminary draft report with maps identifying reservoir breaklines ["breakline" is a term used to define a zone of potential terrain activity around a reservoir following filling] was produced in-house by the Geotechnical Department (B.C. Hydro, 1984(a), Report No. H 1681), using the Klohn Leonoff and Pedology Consultants terrain data.

In addition to the larger and more formal terrain studies mentioned, several construction materials and other exploration reports were prepared which contain site-specific terrain data used in this interim terrain and geological resources impact assessment.

An overview assessment of potential project terrain impacts based on all data collected to the end of 1983 was completed by the Environmental and Socio-economic Services Department of B.C. Hydro and findings are reported here. Pedology Consultants Ltd. reviewed the latest projects description and assisted in the preparation of this interim report.

(ii) Transmission Area Studies

A preliminary transmission route assessment co-ordinated by Ian Hayward and Associates, was completed in 1982 (Hayward, 1982). The Terrain/ Hydrology and Mining section of this study was conducted by Thurber Consultants Ltd. The report provided a preliminary description of potential project impacts on the terrain hydrology and mineral resources for all the corridor alternatives evaluated. This study provided an assessment of possible impacts and assisted in the selection of preferred corridor(s) for detailed study.

Tera Environmental Consultants was selected to conduct the terrain/hydrology portion of the detailed study. Inventory data sources and air photos and maps were assembled and the air photos were interpreted and pretyped. This contract was only partially completed due to project deferral. As a wind-down assignment Tera and J.M. Ryder completed terrain mapping at a scale of 1:50 000 for two previously unmapped areas, located between the area mapped by Pedology Consultants in 1982 and terrain maps available for the Nass basin (published by the B.C. Ministry of Environment). In addition to the maps, Tera and J.M. Ryder provided a short supplementary report and site description notes. (Tera Environmental Consultants Ltd. and J.M. Ryder and Associates, 1983.)

In order to prepare an interim assessment of potential transmission line impacts, an overview study of the preliminary route selected by transmission engineers was conducted by Environmental and Socio-economic Services Department staff. Consultants J. Ryder and Tera's P. Jordan attended the field investigation portion of the interim terrain assessment and provided comment. This assessment did not include further assessment of mining impacts, as this could be subject to significant change during project deferral. In addition, preliminary studies indicated a low potential for transmission line impacts on mining in this area.

(b) Resource Summary (see Fig. 5-3)

(i) Generation Area Resources

The landscape of the study area, including soil and terrain features, is mainly related to the last glacial period (Fraser Glaciation 25 000 to 10 000 years ago) and to post-glacial events and processes.

A. Stikine Canyon Area

In the Stikine area, glaciation of the plateau resulted in the deposition of abundant unconsolidated materials in the valleys and uplands. Glacial till (moraine) characteristically mantles the plateau surfaces and upper valley slopes with bedrock and colluvium dominating at higher elevations. Major river canyons such as the Grand Canyon of the Stikine, Mess Creek, and steep-sided tributaries are often deeply eroded into bedrock. Toward the upper end of the Grand Canyon, areas exist where thick sequences of stratified glaciofluvial and glaciolacustrine sediments and till occur. Upstream of the Grand Canyon, the Stikine and Klappan rivers and other tributaries and valleys are much broader and dominated by glaciofluvial and fluvial deposits.

The most significant active geomorphic processes affecting the Stikine area occur along the side slopes and floodplains of the major rivers and their tributaries and along the glacially oversteepened, upper valley slopes. Flooding and erosion occur along the lower terraces bordering the Stikine River, above and below the Grand Canyon, Klappan River, parts of Tanzilla River and McBride and Beggerlay creeks. The bedrock canyons of Mess Creek, Grand Canyon, and part of the Tuya are subject to hazardous rockfalls and slides. Massive slump failures in thick, unconsolidated sediments occur on the Tahltan, Tuya, and Tanzilla rivers and on the Stikine River at the upper end of the Grand Canyon. Further upstream on the Stikine and Klappan rivers the slope failures are mainly debris flows in kame terraces which are being actively eroded. Many narrow, steep-sided valleys, particularly at upper elevations, are subject to snow avalanching, rockfalls, debris slides, and debris torrents.

The Stikine area contains many examples of unique or special landforms. Canyons of the Stikine, Tahltan, Tuya and Tanzilla rivers and Mess Creek plus minor canyons on many smaller tributaries dissect the regional landscape and provide a diversity of landforms, topographic patterns and dramatic visual sites. Within the deeply incised canyons, many waterfalls, rapids, chutes and major slope failures occur. Fluvial and glaciofluvial landforms are prevalent where the main valley systems broaden. Extensive pitted and ridged glaciofluvial deposits are particularly noteworthy along the Klappan Valley. On the plateaus the main features are the many lakes and the isolated ice disintegration features such as esker complexes and large meltwater channels. Some of the unique landforms in the study area are the remnant, post-glacial lava terraces along the Stikine Valley between Mess Creek and Klastline River.

B. Iskut Canyon Area

The landscape of the Iskut area is not as complex as that of the Stikine. The valley slopes are marked by bare rock cliffs, colluvial and talus debris, and thin morainal deposits. The valley floors of Iskut and Ningunsaw rivers and Forrest Kerr and More creeks are mostly broad and gently sloping covered by glaciofluvial and fluvial fans and terraces and extensive active floodplains. The main valley of the Iskut features ridged topography underlain by thin mantles of moraine and colluvium over bedrock. At the northern end of the study area thicker surficial materials representing pre-glacial, glacial and post-glacial deposition occur. Post-glacial lava flows originating from vents southeast of the Iskut-Forrest Kerr confluence have infilled a section of the Iskut Valley and forced the river to cut a steep-walled bedrock channel.

The most widespread natural geomorphic hazard in the Iskut area is snow avalanching, particularly in the More Creek and Forrest Kerr Creek valleys. Often these avalanche slopes and other steep, rock-controlled slopes are affected by rockfall and debris slide or torrent activity. The braided channels of Iskut and Ningunsaw rivers and More and Forrest Kerr creeks are subject to hazardous flooding and erosion processes. Other hazards in the Iskut area are mainly related to erosion and slope instability along river and stream channels caused by undercutting and oversteepening of bank slopes.

In the Iskut study area there are few unique or special landforms. A mineral spring on the Iskut River north of the More Creek confluence is an attraction. Also, the post-glacial volcanic deposits which infilled the Iskut Valley are noteworthy although not as visually appealing as those in the Stikine Canyon. The glaciers and neoglacial features near the Forrest Kerr-More Creek divide are significant. Close to Highway 37 are isolated examples of deglaciation features such as ablation ridges and meltwater channels and many medium to small-sized lakes.

C. Seismicity and Volcanism

Geological studies of seismicity and volcanism indicate that the Stikine-Iskut project, particularly the Iskut project, is located within an area of historical and recent activity. The last recorded volcanic eruption in Canada took place 50 km southwest of the Iskut site near the head of Lava Fork Creek in 1904. The Iskut project is also located about 4.5 km west of a volcanic vent that has been active post-glacially. This vent is part of a regional north-south trending zone of vents related to the Forrest Kerr/Mess Creek fault system. Volcanic eruptions from these vents have generally occurred passively because the basalt released normally is of low vicosity. The Forrest Kerr fault runs under the location of the proposed Iskut reservoir and probably proceeds northward to join the Mess Creek fault system. It is also probably part of a fault system which extends south as far as Stewart. A 3700 year old lava flow stradles the Forrest Kerr fault. The fact that this flow has not been displaced indicates that significant displacements have not taken place along the fault for at least 3700 years.

Seismic records for the Iskut region date back to 1965. Recent seismic stations (1981) established by B.C. Hydro recorded a high level of microseismic activity in 1982 when 30 events of approximately $m = 1$ magnitude occurred. In addition, events of $m = 3.6$ and $m = 2.8$ occurred in the vicinity in 1965 and 1982 respectively.

(ii) Transmission Area Resources

Proceeding along the selected transmission line route from north to south starting near Stikine Canyon, the first area of sensitive terrain encountered is in the vicinity of Morchuea Lake. Organic lowlands are traversed which may contain discontinuous permafrost. Drainage is restricted and road access is not presently available.

Proceeding south, the route traverses an area of moderate instability east of Eddontenajon Lake. Moist till exists in the area due to the presence of shallow subsurface water. Retrogressive slumping may be encountered. The proposed route is located east of the highway but due to terrain restrictions remains within 1 km of the lake as it traverses a number of creeks and water courses that flow into it.

Continuing south, the route traverses wetlands with possible discontinuous permafrost in the vicinity of the Todagin Creek Ranch and possible areas of groundwater discharge and instability east of Kinaskan Lake. While the route is located at least 2 km from the lakes it also traverses a number of tributary streams.

The route from Iskut Canyon to the Bob Quinn collector traverses lava beds and rugged bedrock terrain with unstable sections. There is heavy forest cover.

South of the Bob Quinn collector in Area 3, the Ningunsaw Pass is an area of high elevation, often unstable steepland slopes, and a constricted valley containing bogs and streams of the drainage divide between the Bell Irving and Iskut rivers. This continues from Ogilvie Creek to the Bell-Irving River crossing, a distance of approximately 40 km.

From this point south to the Meziadin collector the proposed route avoids most areas of organic soils and stream crossings are the most significant concern. Road access is available and slopes are moderate.

South of the Meziadin collector the route avoids numerous small lakes and muskeg as it proceeds south toward the Cranberry River. Bedrock ridges unevenly mantled with till are traversed. In this section the route passes through an area of limited existing access.

As the route proceeds south to its final destination at the Telkwa substation it passes through one additional area of potential concern. This is an unstable short section of slumping till over gravel in close proximity to the Kitseguecla River.

(c) Expected Impacts (See Fig. 5-3)

(i) Generation Area

Terrain and geological resources in the development area would be impacted by the following activities:

1. Construction facilities, such as:

    - access roads
    - campsites
    - building sites and storage areas
    - borrow and spoil sites
    - airstrips and helicopter staging areas
    - waste disposal sites

2. Reservoirs

    - innundation
    - beaching effects and creation of new wetlands
    - drawdown effects
    - mass movement effects

These potential effects are discussed by project area below.

A. Stikine Area

Access

In the Stikine area, site-specific problems could arise from locating roads across deep organics, some of which contain relict permafrost, on the Klastline Plateau. This would not only be a problem during construction but could continue for the medium term. On the north side of the Stikine River, site-specific and local impacts lasting for the medium term could result from channel bank erosion at the road crossings of the numerous gullies and major streams such as Blamey and Latham creeks. This also applies to the proposed relocation of Highway 37 on the north side where it skirts two gully systems. Site-specific impacts may arise during construction of the Tanzilla Project cat trail on the north side of the Stikine River. Erosion and instability of the valley slopes are possible. Site-specific problems lasting from the construction period to short term are also likely if the B.C. Rail right-of-way is relocated further upslope on the north bank of the Stikine. Erosion and instability of fine-textured soils are likely to occur.

Borrow Areas

Borrow pit and construction site impacts are mainly site-specific and may last from the construction period to the medium term. Impacts on a local scale may be significant if a borrow pit is adjacent to a river channel where erosion and downstream sedimentation could be a problem. In the Stikine area, borrow Areas 1 and 14 are both located adjacent to the Stikine River. Because

Area 1 will be flooded by the Stikine reservoir, erosion will only be a concern during construction. However, Area 14 is downstream of the Tanzilla Project and erosion of the gravel terraces could affect the river, at least for the short term. Till extraction from Area 15A, further upstream on the Tanzilla River, could cause short-term stream sedimentation impacts. This may also occur for Area 15.

There is no suitable spoil area below the future reservoir level for the 11 x $10^6 m^3$ of overburden requiring excavation from the Box Canyon. While there are no significant limitations to reclaiming these borrow areas it may be difficult to satisfy visual concerns at an acceptable cost. Revegetation would also be a problem if Area 8 is used as a borrow site. This is located in the Spruce-Willow-Birch Zone where climate and soil development is not conducive to vigorous plant growth.

Terrain Sensitivity and Stability

The study of terrain stability and sensitivity of the proposed Stikine Canyon and Tanzilla reservoirs shows that areas which have been subject to major and massive landslides are those in which there is greatest concern for potential slope instability induced by reservoir ponding (Klohn Leonoff Consultants Ltd., 1980; 1982; 1983). The three main areas of concern are: north bank, just upstream of the proposed Tanzilla damsite; south bank, just upstream of Stikine Canyon damsite; and south bank, at the upper end of the Grand Canyon. Further upstream there are isolated areas which are potentially subject to large or major land movements under reservoir operating conditions. Impoundment will also cause surface soil erosion by wave action and changing water levels which will affect mainly fine-textured materials exposed along various stretches of the shoreline of the proposed Stikine Canyon reservoir. During drawdown fine sediments exposed on terrace surfaces will be susceptible to wind erosion. New wetlands may develop in limited areas along terrace flats adjacent to the upper ends of the proposed reservoir.

The stability of the proposed reservoir shorelines will, for the most part, have site-specific impacts from the short to long term. Four areas (Area T1 near the Tanzilla damsite, Area Z1 and Z2 on the Stikine Canyon reservoir and an area immediately upstream of the More Creek damsite) have the potential to produce significant landslides and reservoir waves. These are the subject of ongoing geotechnical studies by B.C. Hydro and results to date are reported separately. While large single event movements in the order of 10 x $10^6 m^3$ may occur, no indications have been found that these would be rapid.

Reservoir Innundation

Reservoir flooding will accelerate slide activity in a number of other areas but on a smaller scale. These include both banks above the Stikine Canyon damsite, the north bank in the vicinity of Latham Creek, the south bank east of Highway 37, gullies on the north bank east of Highway 37, the north bank west of the Klappan confluence, the west side of the upper Klappan Valley, the area around lower Beggerlay Creek-Stikine confluence, and portions of both banks further east on the Stikine. The slide potential is lower where surficial deposits are thinner; minor sloughing and sliding, however, will continue. Wave erosion and drawdown will keep the slopes active but regression will not be as extensive as the areas under detailed study because bedrock is closer and the headscarps should stabilize in the short to medium term. Most other areas along the Stikine and Klappan valleys will only be subject to some sloughing and isolated sliding where beaching and minor slope undercutting is taking place. Shoreline regression will be very limited and slope adjustments should be complete in the short term. Wind erosion will affect the large drawdown areas.

Unique and Special Landforms

There are unique or special landforms of local to provincial significance which will be affected over the long term by the Stikine-Iskut development. Most importantly, large sections of the Grand Canyon of the Stikine will be flooded. This would be a loss of provincial significance, as parts of this unique geomorphic feature including the main canyon, tributary canyons, and many spectacular waterfalls, rapids, and chutes would be inundated. At the same time, roads built for the project will provide access to view sites along the canyon which are not available at present. The unique lava terraces along the Stikine River between Mess Creek and the Klastline River will be unaffected by the project.

Local and site-specific impacts will occur where landforms are removed or modified through the development of borrow pits, spoil areas, roads, and construction facilities. Deglacial features such as esker ridges or hummocky terraces are a main source of sand and gravel.

Where they occur at locations such as the confluence of the Stikine and Klappan rivers, they may be totally or partially flooded by the impoundment. Road construction and townsite facilities will provide an opportunity for viewing many spectacular sites ranging from local to provincial significance such as the Blamey Creek waterfalls and the Grand Canyon of the Stikine. Although, the value of some of these features may be lessened by the presence of the reservoirs.

B. Iskut Area

Reservoir Effects

The Iskut Canyon and More Creek reservoirs should not cause significant shoreline instability because the slopes are mainly bedrock controlled. Minor talus and colluvial slides may accelerate on inundation and these can be expected to continue over the medium to long term with little impact. Many steep slopes, particularly along Forrest Kerr and More creeks, are subject to debris torrents and rockfalls. These processes will continue to transport debris into the valleys but the rate will not be changed by reservoir inundation. The lower slopes will be subject to minor beaching and limited sloughing, especially where granular material in large fans and terraces is exposed during drawdown. The drawdown areas at the upper ends of both reservoirs are quite extensive and may be subject to long-term wind erosion.

The main long-term impact in the Iskut area would be the partial flooding of the recent lava flows near Iskut Canyon. These are regionally important and although impacts will occur, road access to this area could allow the development of a preservation site. It may also provide a site to view Iskut Canyon. The permanent access roads will provide many good, local view sites of the Iskut Valley and lower More Creek Valley. There will be minimal impact on the local mineral spring as it is above the impoundment level and access to it will still be difficult. Some of the large, braided floodplains of Iskut River and More and Forrest Kerr creeks will be flooded. These are of local significance and More Creek is valued as an excellent example of a glacier-fed stream regime.

Seismicity and Volcanism

Engineering assessment of the risks associated with seismicity and volcanism has not been completed. However, it is expected that the level of seismic and volcanic risk which would be acceptable and which would permit construction of the Iskut Canyon project would have relatively minor environmental implications.

Access Impacts

Road construction for the Iskut Project would have mainly site-specific impacts during construction as temporary roads are built on the floodplains of Iskut River and More Creek. These will be subject to washouts, floods, and continual erosion. After construction, the roads will be below minimum water levels of the reservoirs. The permanent access roads would have potentially limited impacts. Channel erosion or instability could be a medium-term problem at the Iskut River crossing (More Creek Road) and at the crossings of Ningunsaw River and another major west-flowing tributary of the Iskut.

Site-specific erosion and instability problems will exist for the long term in places where roads traverse steep slopes along valley sides.

Borrow Areas

In the Iskut area, gravel extraction involves disturbance of active floodplains which would eventually be inundated by the reservoirs. Erosion impacts are therefore confined to the construction period. These are not considered serious, as the Iskut River carries heavy sediment loads under natural conditions. Gravel extraction from Area 2, part of the Iskut floodplain above the upper end of the reservoir, could cause local, construction and short-term impacts, such as soil erosion and river sedimentation. Removal of till from Areas 1 or 4 may have site-specific erosion impacts during construction. These areas are very wet and may require proper drainage to minimize erosion and allow revegetation. Till extraction adjacent to the Ningunsaw River (Area 4A) may cause site-specific erosion during construction and for the short term. Construction facilities and small borrow sites and spoil areas adjacent to the project sites will likely experience only minor, site-specific erosion problems during the construction period. There are no significant limitations to reclaiming and restoring these areas after construction.

(ii) Transmission Area

A. General

Most of the adverse impacts of transmission lines on terrain and geology result from access road construction, right-of-way clearing and tower placement. These impacts range from short- to long-term duration and are primarily associated with soil erosion and stream sedimentation or disturbance of unique or sensitive terrain which is difficult to reclaim. Disturbance and altered drainage patterns may also increase landslides and mass movement.

Care in route selection and line construction could reduce potential impacts in most transmission line areas. Precise terrain impact assessment at the preliminary planning stage is difficult. Additional field study and more precise route and road information is required and some of this information may not be available until the project nears or is under construction. However, most significant concerns are identified during the early planning stages and less serious problems can be mitigated at the detailed design and construction stage.

B. Site-specific

The proposed transmission route has potential for impact on terrain (Fig. 5-3) and hydrology at the following locations: 1) lowlands in the vicinity of Morchuea Lake; 2) lava flats and steepland slopes near the Iskut Canyon damsite; 3) the Ningunsaw Pass area; 4) that portion of the route that parallels the Kitseguecla River; and 5) numerous stream crossings, particularly those where disturbance would be required in close proximity to the banks e.g. Hanna and Tintina creeks area near Meziadin.

Generally the balance of the route from Tanzilla to the Telkwa River crossing has a lesser potential for impact than the areas mentioned above. Most impacts in this section will be related to access requirements. The last section of the route from the Telkwa River to the substation has the lowest impact potential. Terrain in this area has a low relief; access is available and the forest cover is light.

(v) Economic Geology

The economic geology study provides extensive documentation of geology, mineral potential and mineral claims in the generation projects study area. In brief, the region has extensive deposits of base metals, coal, some precious metals, and various other minerals, but development of these deposits into working mines is hampered by remoteness, as evidenced by potentially high transportation, labour force, energy costs.

The economic geology study identifies three potential effects of the project upon mineral resources of the region. These are 1) possible direct negative effects caused by flooding of potentially valuable ore bodies in the reservoir areas; 2) possible indirect positive effects associated with improved access; and 3) increased availability of electrical energy. The economic geology report indicates that only three mineral prospects lie within or adjacent to the proposed reservoirs. These include the Tsetogamous Creek, PML73, and Bud showings in the Stikine Canyon reservoir. All three prospects are believed to be small and of no commercial value, although published information is available only for the Bud showing. No coal has been found within the reservoir areas. Given this outlook, it seems appropriate to assume that mineral values directly affected by reservoir flooding are negligible. Potential benefits to mineral resource development could include power and improved access.

Based on preliminary investigations of mineral inventories, no areas of significant impact potential have been identified within the preferred transmission line route. The planned Bulkley Valley colliery development lies south of the route near Goathorn Creek and should not be affected.

(d) Conclusions

Terrain impact concerns in this development area range from reservoir-induced seismicity to surface soil erosion caused by construction of project facilities. Geotechnical and other engineering studies should identify all mass movement potentials which could be caused by the project. Assuming these major events are studied and dealt with appropriately, the remaining terrain effects will result from reservoir inundation and drawdown effects, site construction and development of new access. Areas of greatest sensitivity to disturbances are high elevations (subalpine and tundra zones), organic terrain with permafrost, and steeply-sloping fine textured soils. For the most part, the terrain effects associated with these sensitive terrain impacts can be handled by application of standard construction procedures. To ensure that these procedures are adequately planned, a development and reclamation plan, including a materials handling plan, would accompany the energy project application.

5.2.3 Vegetation

(a) Summary of Studies Conducted

Studies to determine and map existing vegetation types have been undertaken in all three study areas. In addition to its own value as a resource, data on vegetation are also important to, and have been used by, other disciplines notably wildlife, visual, and hydrology.

Initial overview studies of vegetation were carried out in 1978. This work was undertaken by B.C. Hydro (B.C. Hydro, 1978a,b) and concentrated on the area of the proposed dams and reservoirs. Data were obtained from existing published reports; no field work was done. More detailed mapping and descriptions of vegetation types was undertaken between 1979 and 1983 (Techman/Ceska, 1983). These studies were supplemented by detailed vegetation mapping to a scale of 1:50 000 by Talisman (Talisman, 1984b).

Preliminary vegetation studies for the transmission component of the project were undertaken during 1981 (Tera, 1982a). The study area included part of Area 2, Area 3 and, in addition, other potential transmission corridors. Existing data, examination of aerial photographs and limited ground and helicopter surveys were used to map biogeoclimatic zones and vegetation types at a scale of 1:250 000. More recently, during early 1983, limited additional mapping of biogeoclimatic zones, subzones and vegetation associations were undertaken along the proposed corridor(s) in Area 3 (Tera, 1983).

To study changes in vegetation downstream of the project, Area 1, a set of permanent vegetation plots were established near the Darsmith test reach during 1983. It is intended to re-examine the plots in future years to determine compositional and structural changes in vegetation types. These plots are designed to provide information on vegetation due to changes in hydrology expected with the project in place.

(b) Resource Summary

The location of biogeoclimatic zones in the study Areas 1, 2 and 3 are shown on Fig. 5-4.

Study Area 1 contains both coastal and interior vegetation types and types transitional between these major categories. The vegetation at the delta of the Stikine River consists of low growing herbaceous plants growing on open tidal marshes. Upstream of the tidal areas, the floodplain valley contains stands of cottonwood on alluvial islands with mixed coniferous forests of Sitka spruce and western hemlock on higher areas. Between the U.S. border and Glenora, the vegetation changes from coastal forests, to mixed transitional ones, to Interior types. The cottonwood and Sitka spruce tree species are replaced by aspen and white spruce. North and east of Glenora, most of the observed vegetation consists of secondary successional plant communities established after numerous widespread forest fires.

The biogeoclimatic zones of Area 2 include those typical of the interior in addition to those transitional between interior and coastal. Existing vegetation in the reservoir areas of the Stikine and Tanzilla projects include mixed alluvial, trembling aspen, black and white spruce and lodgepole pine types. The deeply incised river canyon provides an environment suitable for a large number of rare grassland steppe plants and Ecological Reserve Application (ERA) No. 133 has been filed to preserve them (Fig. 5-4).

Vegetation in the area of the Iskut River development shows the influence of maritime climatic conditions. Vegetation consists of western hemlock and Sitka spruce forests with cottonwood along the river valley bottoms. Lodgepole pine is predominant in the lava flats area adjacent to the proposed Iskut Dam.

A complete list of vegetation types in the areas of the reservoirs is given in Table 5-3.

Along the transmission line route the vegetation is characterized by dense coniferous, mixed coniferous-deciduous (mostly aspen) and deciduous forests. Two major burn areas are present, one near the location of the Stikine Collector, the other south of Burrage Creek. Regrowth in these areas has been slow with lodgepole pine and shrubby species predominant. The numerous bogs along the route are surrounded by shrubs, black spruce and riparian vegetation. Ecological Reserve Applications No. 129 near Zechtoo Mountain, No. 127 near Elahcezetle Mountain, and No. 125 near Natadesleen Lake are located along or near the proposed transmission route. A list of vegetation types along the transmission route is given in Table 5-4.

Area 3 traverses four biogeoclimatic zones. Vegetation resources of this large area consist most of mature or overmature forests of western hemlock and subalpine fir. Along the southern portion of the route, lodgepole pine and western red cedar are also present. Areas of dense shrubs exist in a number of locations, particularly in the Ningunsaw/Snowbank Creek area on avalanche debris flows. Wetlands/shrub fens are present in numerous locations but of note are those in the Beaverpond/Snowbank creeks valley, near Meziadin lake and near Dennis/Aldrich lakes. A list of vegetation associations along the transmission line route is given in Table 5-4.

Ecological Reserve No. 59 located at the confluence of the Ningunsaw River and Alger Creek is of note. It was established to preserve plant associations of three biogeoclimatic zones namely Interior Cedar-Hemlock, Engleman Spruce-Subalpine Fir and Alpine Tundra. Four ecological reserve applications have been filed along or near the transmission line route; ERA No. 123 south of Skowill Creek, ERA No. 122 east of the confluence of the Bell-Irving and Bowser rivers, ERA No. 121 around Mt. Bell Irving and ERA No. 155 around Hudson Bay Mountain (Fig. 5-4). The mapping of locations of rare and endangered species of vegetation has not been completed.

(c) Impact Assessment

In Area 1, any impacts on the vegetation resource would be related to the changes in the Stikine River water levels and flow regime. It is assumed that these changes would result in increased stability of the river banks, and lower rates of erosion and sedimentation. A possible effect upon the floodplain would be a gradual increase in the area of mature conifer-cottonwood forests. Areas of open gravel and riparian vegetation would increase due to exposure through generally lower river levels. In stable areas these newly exposed and vegetated riparian habitats could give way to the more mature conifer-cottonwood vegetation. Changes would be of local extent and of long-term duration.

The areas of each vegetation type flooded by the proposed reservoirs (Area 2) are given in Table 5-3. Only the lowest elevations of ERA No. 133 would be flooded by the Tanzilla reservoir (see Fig. 5-4). However, the Stikine Canyon dam and reservoir would alienate the easternmost quarter of the ERA. The southern tip of ERA No. 130 would also be flooded by the Stikine Canyon reservoir.

The transmission line would alter the vegetation on approximately 2434 ha of right-of-way. These would be cleared of all trees and in most cases revegetated with grasses (originally) which would in time, be succeeded by low growing herbaceous and shrub species. Vegetation associations through which the transmission line would pass are given on Table 5-4 together with the area of each affected. Ecological Reserve Applications No. 129 and 127 would be crossed by the route.

In Area 3, the vegetation associations impacted by the transmission line are summarized in Table 5-4. Ecological Reserve No. 59 in the Ningunsaw Pass would be avoided. However, Reserve Applications

Nos. 123, 122 and 121 would be crossed by the route (see Fig. 5-4). Total area of land affected by the transmission line amounts to 6341 ha. The direct impact would be the loss of tree cover and maintenance of low growing species along the right-of-way opening through the forested lands. In time, the increased growth of shrubs may be expected to be useful forage for wildlife. Indirect impacts may also occur stemming from changes in surface drainage patterns generally favouring those plant species adapted to drier conditions.

(d) Conclusions

Existing vegetation would be lost due to flooding along the Stikine and Iskut rivers and More and Forrest Kerr creeks. This amounts to 16,100 ha. Along the transmission line, vegetation would be altered with the removal of tall growing trees and enhanced shrub growth which may provide improved sources of food for animals. Downstream of the project, hydrologic changes are expected to lead to an increase in the area of mature cottonwood forests.

5.2.4 Agriculture

(a) Summary of Studies Conducted

(i) Generation and Downstream Areas (Areas 1 and 2)

In January 1982, Talisman Land Resource Consultants (Talisman 1982) completed a preliminary agricultural overview of the Stikine-Iskut Hydroelectric Development. This study provided an estimate of the agricultural capability and present production within study Areas 1 and 2. In addition, development potential and possible project impacts were discussed.

Overview study findings indicated that further work was needed, particularly to evaluate the extent and capability of agriculturally suitable soils within the proposed Stikine Canyon reservoir. Fieldwork was also needed to document existing agriculture within the region and study area potential. Terms of Reference were written and studies initiated to undertake a soils, surficial geology and land forms inventory. The soil and terrain inventory was completed by Pedology Consultants in 1983 (Pedology, 1983). Concurrently a detailed agricultural impact assessment was undertaken by Talisman Land Resource Consultants, but work was only partially completed at the time of project deferral. In 1984 Talisman produced a draft report including results of their 1982 field studies and an agricultural capability assessment of Pedology Consultants' detailed study area soils data (Talisman, 1984a).

(ii) Transmission Area (Area 3)

A preliminary transmission route assessment was completed in 1982 (Hayward, 1982). The agricultural portion of this assessment was conducted by Tera Environmental Consultants Ltd. (Tera, 1982b). This report provided a preliminary description of potential agricultural impacts within a number of corridor alternatives, within and beyond study Areas 2 and 3. This study evaluated the extent of possible impacts within various corridor alternatives and assisted in the process of selection of preferred corridors for detailed study.

A detailed route selection and impact assessment of selected corridor alternatives was initiated in 1983 utilizing Talisman Land Resource Consultants for the agricultural portion. This contract was only partially completed due to project deferral. An inventory of lands of agricultural capability within the study corridors was provided. However, no field checking of present agricultural use or lands of questionable capability was conducted (Talisman, 1983).

In order to provide an interim assessment of potential agricultural impacts, an overview study of a route selected by transmission engineers was completed by Environmental and Socio-economic Services staff.

(b) Agriculture Resource Summary

(i) Generation and Downstream Areas (Areas 1 and 2)

A. Present Agriculture

Present agriculture production within the study area is limited, due primarily to the distance from population centres and markets. In total, approximately 180 ha are cleared in numerous locations along the Stikine River primarily downstream of Telegraph Creek, with 130 ha in cultivation. Four holdings account for 75 percent of the cultivation. All but approximately 5 ha are used for forage production, primarily pasture. A wide range of vegetables and a few small fruits and tree fruits are produced on these 5 ha which are dispersed over a number of sites. Production surplus to individual needs is generally sold locally. In a few cases produce has been sold in more distant centres within the region such as Wrangell and Watson Lake. Forage crops and feed grains are produced on the remaining lands, primarily for the wintering of horses. The consultant estimated the regional horse population at 400 head. They utilize native range primarily during the summer months. Much of the winter forage requirements reportedly are imported.

Although attempts have been made at beef cattle production, no viable operations have established to date.

One operator presently produces hay, oats and some vegetables on 8 ha of this land located within the proposed Stikine Canyon reservoir just west of the Stikine Highway 37 bridge crossing. This operator also holds a grazing permit located in the same general area and partially within the proposed reservoir. It covers an area of 300 km^2 and authorizes year-round grazing for 18 horses.

B. Potential Agriculture

Studies confirm that land in the Stikine Valley, primarily that which is downstream from Telegraph Creek, possesses climate and soils of high capability for agricultural production, especially when one considers the northern latitude. Approximately 4500 ha of land of Class 2-4 agricultural capability (improved) is located along the fluvial lowlands extending downstream from Eight Mile Creek to the Chutine confluence, a distance of approximately 60 km. Fifty percent of this land has high capability (Class 2-3). An additional 9650 ha of Class 5 land is found on the plateau-like areas above the fluvial terraces. This land has limitations (largely climatic) that restrict its capability primarily to the production of perennial forage crops. Although data are limited, indications are that climate capability decreases rapidly at higher elevations due primarily to a lack of heat units but also to a reduced frost-free period. At an elevation of approximately 600 m, climate restrictions generally limit agricultural capability to Class 6, which is considered non-arable.

No other lands of significant agricultural potential have been identified in study Areas 1 or 2. A few microsites with a satisfactory climate for restricted horticultural production exist in the lower Iskut and Ningunsaw valleys. However, the landforms at these locations are largely unsuited to cultivation due to such factors as prolonged wetness, inundation and stoniness. One individual produces vegetables on a small terrace in the upper Ningunsaw Valley near Bob Quinn Camp. This is above the area which would be inundated.

The only land with significant potential for cultivation within the proposed reservoirs is located in the vicinity of the Highway 37 Bridge crossing the Stikine River. An estimated area of 625 ha of Class 3-5 agriculture capability exists at this site. However, the agricultural capability ratings in this area have not been confirmed.

Outside the areas described, lack of physical resources limits the agricultural potential to grazing by horses or possibly cattle. Areas suited to grazing are limited by topography and low productivity of the native range which is particularly unsuited to beef grazing. If beef production were to develop, most of the grazing would likely require improved pasture.

Studies also indicate that the potential of the study area is significantly restricted by marketing factors, primarily distance to market. Other limitations include access restrictions, lack of infrastructure and high costs of production. Although significant land is available, the consultant considered that these limitations would restrict future development of horticultural production in the study area to 13 ha until the year

2000. No unique production opportunities were identified for the study area and any commodities produced would have to compete with other sources of supply. Further information on development potential is discussed under the impact assessment section, particularly with regard to beef production.

(ii) Transmission Areas (Areas 2 and 3)

Present Agriculture

Present agricultural activity and land with potential for cultivation is extremely limited along the proposed Stikine-Iskut transmission route. Three locations of existing agricultural activity would be traversed in study Area 3. These are small cultivated parcels of Class 3-5 agricultural land, which are primarily utilized for cereal grain or hay production. Short distances of less than 2 km would be traversed. Proceeding from the Telkwa Substation, the first agricultural property affected is approximately 4 km on route. A small grain field and farmstead is traversed for a distance of approximately 2 km. The second farm affected is approximately 1 km east of Goathorn Creek. Here a parcel of Class 4 agricultural land is traversed and the route passes within 500 m of an apparent farmstead. The third agricultural parcel traversed is a hay field of Class 3-4 capability at the Skeena River crossing site. A small cultivated bench, less than a kilometre wide, would be traversed.

No existing agriculture is affected by transmission lines in study Area 2, although a small section (less than 1 km) of improved pasture in the vicinity of Todagin Creek would be encroached upon. This is Class 6 or 7 land and is not a suitable agricultural area, due to climate limitations.

Climate data indicates a frost-free period of 21 days with 552 growing degree days. Horses are likely raised on the property for private recreation or guiding.

(iii) Potential Agriculture

Although it is largely undeveloped, most of the land along the 30 km of route between the Telkwa Substation and Goathorn Creek has the potential for cultivation. It is generally rated Class 4 and located within the agricultural land reserve. Land along the route north of the Telkwa River with the exception of the small land base previously discussed at Skeena Crossing, has low agricultural potential. It is generally unsuited to cultivation due to climate and soil restrictions, and high development costs. Some sections may be utilized for livestock grazing but the natural carrying capacity of land along the route is limited, primarily by the heavy forest cover and short growing season. Long distances to markets and the lack of suitable land for cultivation (winter feed supplies) also serve as major deterrents to development of a livestock industry.

(c) Expected Agricultural Impacts (see Fig. 5-3)

(i) Generation and Downstream Areas (Areas 1 and 2)

A. Existing Agriculture

One existing agricultural operation is located within the proposed Stikine Canyon reservoir, approximately 4 km downstream of the Highway 37 Bridge. Approximately 8 ha are cultivated for production of hay and grain, which is utilized for the wintering of horses. The net annual value of possible production from this land, if irrigated, is estimated at $1855. The actual net value of present production is unknown but would be significantly lower than this amount. Upper reaches of the reservoir and adjoining lands are utilized for the pasturing of horses. Approximately 20 horses graze the area for at least a portion of the summer months. The annual agricultural value of this range was estimated to be $5400. Talisman (1982) considered that both production activities would be foregone if the project proceeded, since they did not feel that an operation using the remaining grazing land would be viable. Whether or not this is indeed the case, would require further evaluation of range and overwintering alternatives.

B. Potential Agriculture

In addition to the cultivated land previously described, in excess of 600 ha of associated lands, potentially of Class 3-5 agricultural capability, would be inundated. The full extent of these lands and their capability is uncertain due to insufficient crop history, climate and soil data available at the time of project deferral. Under the circumstances, the consultant chose to be optimistic and rated the lowest elevation sites as possessing a Class 3 climate for agriculture, or one class below the Class 2 capability of the best land below Telegraph Creek. It is more likely that this area possesses a climate capability of Class 4 at best which could reduce potential impacts. This may or may not be significant depending on assessments of future development opportunities and the extent to which other limitations described below are considered.

Although production costs would be high, Talisman felt that some land would be required for beef production in the future. An evaluation model indicated that it should be possible to produce hay in the study area at prices below the cost of importation. A maximum possible scenario of grass-fed beef production for local consumption was developed. Optimistic production and consumption levels were used and it was assumed that beef produced could compete with imports. The report indicated that this is an upper bounds estimate. However, even as an upper bounds estimate this assessment appears overly optimistic since beef production trends presently are away from development of local or regional markets, and with such high feed production costs it is unlikely that the beef produced would compete with imports to the region. Nevertheless, with these assumptions and a shift to local forage production for overwintering horses (presently largely imported) it was estimated that the region could support an additional 180 ha of cultivation at present and 500 ha by the year 2000. Although the consultants expected that most of the projected development would occur in the Telegraph Creek-Glenora Area, 125 of the 500 ha was projected to occur within the proposed reservoir in the vicinity of Highway 37.

The projected land requirement for agriculture included an additional 13 ha to meet future regional in-season fresh fruit and vegetable demands. It was forecast that this land would be developed on the higher capability sites downstream of the proposed reservoirs. Approximately 80 ha was also included to replace imported forage for the present horse herd.

The net annual value of present and potential crop production lost as a result of the project is estimated to be $34,980. Using a real discount rate of 8 percent, the present value of foregone opportunities to agriculture would then be estimated at $435,000.

It is apparent that potential project impacts on agriculture are small, even with a worst case scenario. Total land loss represents in the vicinity of 5 percent of the regional resource base, which is largely unutilized. The loss of approximately 132 ha of projected production, of which only 7 are presently developed, possesses no threat to the future viability of agriculture in the region. The forecast land requirement of 513 ha (excluding horses) can easily be met on the conservatively estimated remaining 4500 ha of Class 2-4 and 4900 of Class 5 land. The potential lost production is not anticipated to cause any site-specific local hardships since beef and vegetables are readily transported from sources within and outside the region.

Viability of the local Highway 37 tourist and guiding industry, which is expected to continue to require horses for transportation, could be maintained through a program of local range improvement to compensate for loss of grazing land and/or feed freight assistance for those affected. The transmission right-of-way might also be utilized.

The project would also benefit future agricultural development through an increased local market (population) and off- farm employment opportunities. No attempt was made to quantify these benefits but it is expected that they would be significant.

C. Groundwater Recharge

Possible loss or decrease in groundwater recharge to low-lying terraces near the Chutine River is a potential problem which was not studied. Terrain studies indicate that most terraces are recharged by surface and upslope water sources but it is possible that plant growth on some terraces near the Chutine River are influenced by groundwater recharge from the Stikine River.

(ii) Transmission Areas

The proposed route and alternative to Skeena Substation avoids the majority of present and potential agricultural land in the Bulkley and Kitwanga valleys, around Terrace and Aiyansh. The most significant land base potentially impacted is a 30 km section between the Telkwa Substation and Goathorn Creek. This is largely undeveloped Class 4 land. However, two existing cultivated areas would be traversed for short distances of approximately 2 km and one farmstead would require relocation. A third agricultural parcel would potentially be affected at the point where the proposed route crosses the Skeena River. A hay field would be traversed for a distance less than 1 km.

Long-term impacts associated with tower interference are expected to be relatively minor due to the area's limited potential for irrigated agriculture. Minor amounts of land loss from towers and operator time loss through required avoidance are the main impacts anticipated.

Negative impacts to agriculture due to transmission lines would result primarily from placement of towers on land currently in production or land which has agricultural capability. Based on an estimate of four towers per kilometre per line and a last production area of 0.04 ha per tower this equates to a maximum of 16 ha. If this land eventually became fully developed for forage production (which is unlikely) it would produce in the vicinity of 80 tons of hay per year. This does not represent a significant potential loss to the agricultural resource base of the region.

Short-term project effects such as crop loss, production interference and soil compaction would be low due to the small area of cultivated land traversed.

Some benefits are expected to accrue primarily in Area 3 through increased grazing opportunities along the right-of-way. These have not been quantified but it is not expected that they would be large due to the low grazing potential of adjoining forest land and limited opportunities for expansion of the beef industry that exists in much of the study area.

(d) Conclusions

Existing agricultural development in the generation area is dominantly found downstream of the proposed Stikine projects in the Telegraph Creek and Glenora areas. Even with optimistic projections for expansion of agriculture in the future, there appears to be adequate expansion area and better quality land in this downstream area.

Given the most optimistic agricultural development scenario, the generation projects would eliminate approximately 132 ha of agricultural land. Transmission towers would interfere with an additional 16 ha. It is concluded that losses of this magnitude for the agricultural sector are not significant on a regional basis.

5.2.5 Forestry

(a) Studies Completed

Evaluation of the forestry resources of the Iskut and Stikine valleys (Area 2) was started in 1978 when an overview study was completed (B.C. Hydro, 1978a, b). These studies relied on existing published information and no field work was undertaken. More detailed studies were carried out in 1980 (Forestal, 1980). Field reconnaissance was undertaken to accurately determine the forestry resource present and to assess the effect of the project on the use of this resource. In 1982, two addenda to the detailed study were completed which examined the economics of developing the forest resources in Area 2 (Forestal, 1982a, b).

Preliminary forestry studies for the transmission component were undertaken in 1980/81 (Hamilton, 1982). Inventories of the forest resources, access and forest management activities within the proposed transmission corridors were completed. Existing forest industry investments and developments were researched with the aid of government agencies and industry officials. Evaluation of the corridors considered potential impacts of the transmission line on development of the resource, management practices and industrial forest operations. The present assessment of transmission effects is based on this information.

There have been no studies carried out by B.C. Hydro in the area downstream of the project Area 1. However, inventory information including forest cover maps are available from the Ministry of Forests.

(b) Summary of the Resource

In Area 1, south of the confluence of the Chutine and Stikine rivers, the forests are within the Coastal Western Hemlock Biogeoclimatic Zone (Fig. 5-4). Potential commercial trees include western hemlock, Sitka spruce, balsam poplar and cottonwood. On the floodplains of the Stikine and Iskut rivers, there are extensive cottonwood and mixed cottonwood/conifer stands in all successional stages. Above the floodplain the forests consist of mature stands of hemlock and balsam. North of the confluence of the Chutine and Stikine rivers, the forests are in the Boreal White and Black Spruce Biogeoclimatic Zone. Potential commercial trees include the spruces, true firs, lodgepole pine, balsam popular and cottonwood. This area includes parts of the Boundary and the Iskut Timber Supply Blocks of the Cassiar Timber Supply Area.

The only use made of the forest resources on a commercial basis is the recent cottonwood harvesting operation by Hal-Pac Forest Products near the confluence of the Iskut and Stikine rivers.

There is also a small scale sawmilling operation in Telegraph Creek for local consumption.

Area 2 covers portions of six biogeoclimatic zones. They are the Interior Cedar Hemlock, the Englemann Spruce - Subalpine Fir, the Boreal White and Black Spruce, the Alpine Tundra, Sub-Boreal Spruce, and the Spruce-Willow-Birch zones (Fig. 5-4). Forest cover classification of the land within the areas of the proposed reservoirs are given in Table 5-5. The corresponding timber volumes within these areas are given by species in Table 5-6. From these data, it is calculated that 63.6 percent of the reservoir areas is potentially productive forest land that presently supports an average timber volume of 197.6 m^3/ha. According to the Ministry of Forests records, all lands within the proposed reservoir areas are held by the Crown and are situated in the Iskut Timber Supply Block of the Cassiar Timber Supply Area (TSA).

Area 2 taken as a whole is chiefly mountainous and non-productive with respect to timber. However, there is a tract of forest land along Highway 37 which supports sufficient good quality stands of lodgepole pine, spruce and subalpine fir to be considered economically accessible. There are minor and intermittent logging and sawmilling operations along the highway. This area has also been the source of logs exported via the port of Stewart.

The proposed transmission route would pass through four biogeoclimatic zones of Area 3; they are the Interior Cedar Hemlock (Northern Transitional Subzone), the Englemann Spruce- Subalpine Fir, the Sub-Boreal Spruce and the Alpine Tundra zones. The area extends through the Kalum, Kispiox and Bulkley Timber Supply Areas, including part of Tree Farm Licence No. 1. The timber stands are mainly composed of mature subalpine fir, spruce and decadent hemlock with lodgepole pine on the drier benches. Current logging operations extend from the area near Meziadin in the north to upper Kitsequecla River area in the south. Forest harvesting is not well developed further to the north and south of these areas respectively.

(c) Impact Assessment

To describe impacts of the project on the forestry resource, a projection is first made of the anticipated changes in resource utilization without the project. With development, assessments are then provided. These projections assume:

1. that the B.C. Forest Industry will continue to have a healthy demand for its products;

2. that log export permits would be granted to sell overseas that timber cleared from the proposed reservoirs;

3. that demand for deciduous species would be insufficient to make them economically merchantable; and

4. that the Dease Lake extension of the B.C. Rail line would be completed before construction of the hydroelectric project is begun.

It is recognized that the validity of these assumptions remains uncertain due to the uncertain development schedule for the project, changes in world economy and that of the B.C. Forest Industry and the suspension of construction of the B.C. Rail line.

(i) Without Development

Without the Stikine-Iskut proposed hydroelectric development, the forest resources in Areas 1 and 2 would probably remain almost unused except for occasional small timber sales. In Area 3, there would be further harvesting of the northern portions of Tree Farm Licence No. 1 by B.C. Timber and probably new harvesting operations in Timber Supply Block A of the Bulkley TSA. The timing of these expanding operations would depend upon changes in the world demand for B.C. forest products, i.e. lumber, pulp and paper.

(ii) With Development

For Area 1, changes in flow regimes and flow levels are not predicted to be great enough to affect the growth of the alluvial forest stands, or change the present possibility of log towing on the lower reaches of either river system. Thus, from a forestry perspective there will be no impacts of a measurable nature downstream of the projects.

For Area 2, impacts will be caused by the flooding of productive forest land; the area of land affected and volume of timber lost given in Tables 5-5 and 5-6 respectively. In addition, there would be forest land lost as a result of the clearing for airstrips, camps, and other permanent buildings. The key assumptions made are that there will be a market either locally or overseas, for all merchantable timber to be cleared from the reservoirs and other facilities.

For the transmission line, it has been assumed that widths of rights-of-way will be on the average 30 m wide for a 230 kV line, 120 m for two 500 kV lines, and 170 m for three 500 kV lines. Rights-of-way would cause a loss of 2700 ha of land which has the potential of producing approximately 3200 m^3/annum of wood. A summary of forest land impacts is given in Table 5-7.

The present intermittent and low level harvesting and utilization of timber would not be affected.

For Area 3, it has been assumed that the only impact will be caused by the three 500 kV transmission lines to Telkwa. These would require an average clearing width of 170 m and alienate about 6300 ha of land. This is equivalent to an annual production of approximately 11 200 m^3.

The development impacts caused by harvesting and clearing the reservoir and right-of-way areas will have regional and local medium-term impacts. The cumulative effects of the residual impacts caused by the loss of productive forest lands will have regional and local long-term impacts. However, forest company operations should not suffer materially by this loss of production.

(d) Conclusions

Based on the forestry studies done to date, it appears that there will be no impacts upon this resource in Area 1. For Area 2, the present intermittent harvesting operations are not expected to be affected. However, the proposed project could reduce the Long Run Sustainable Yield (LRSY) of the Iskut Timber Supply Block of the Cassiar Timber Supply Area by approximately 17 percent, i.e. 20 000 m^3/annum. Detailed forestry studies for the proposed transmission line route through Area 3 have not been completed. Preliminary results indicate that the impacts of the proposed project upon the forest companies operating in this area would not be severe.

5.2.6 Water Resources

(a) Summary of Studies

Overview hydrology studies for the Stikine and Iskut rivers were initiated in 1977. The overview reports on hydrology (B.C. Hydro, 1977, 1978a) noted the paucity of data and recommended a basic program to collect additional hydrometeorological data for subsequent engineering and environmental studies.

The major objectives of the hydrology field program to support environmental studies were:

1. to establish test reaches and conduct field measurements to define stage-discharge relationships and grain size composition of bed material on the Stikine and Iskut rivers downstream of the proposed damsites;

2. to obtain measurements of suspended sediment concentrations at Water Survey of Canada (WSC) stations upstream and downstream of the proposed damsites;

3. to install and maintain water temperature recorders at all WSC stations on the Stikine and Iskut rivers; and

4. to make ice observations to document timing and pattern of freeze-up and break-up and areas of open water.

The field program was designed to obtain data on the natural physical environment of the Stikine and Iskut rivers. The results of the field program along with a preliminary assessment of changes in hydrology, sediment transport, river morphology and water temperatures following regulation are contained in B.C. Hydro Report No. H 1110 (1981) (B.C. Hydro, 1981).

In 1982, B.C. Hydro undertook an intensive field program to obtain daily measurements of suspended sediment concentrations at seven WSC stations (plus the United States Geological Service (USGS) gauging station) on the Stikine and Iskut rivers. The purpose of the program was to obtain data to corroborate previous estimates of the life expectancy of Iskut Canyon reservoir and to improve the estimate of the annual sediment budget of the Stikine estuary. Field data and analyses are presented in the Addendum Report on Suspended Sediment (B.C. Hydro, 1982b). Additional field data collected by B.C. Hydro are contained in Addendum Reports on Water Temperature, Test Reaches and Ice Observations (B.C. Hydro, 1982a, c; 1983b; 1984).

In the fall of 1982, B.C. Hydro contracted D.P. Jones and Associates to prepare an environmental hydrology report. The purpose of this study was to integrate and update data presented in previous reports, provide specific analyses to meet the requirements of specialists assessing the effects of regulation on fisheries, wildlife, vegetation, etc., and provide an interpretation of the effects regulation would have on the hydrology, sediment transport and morphology.

To investigate the changes in the thermal regime, B.C. Hydro initiated two studies in late 1982. Schultz International Ltd. in cooperation with Ford, Thornton, Norton and Associates (FTN) were requested to simulate the temperature and water quality conditions in the proposed Stikine and Iskut reservoirs using a computer model. The one-dimensional model "MANAGER" was to be tested using data from Williston reservoir to demonstrate its validity for northern reservoirs and then used to predict conditions, including the efficiency of selective withdrawal, on the Stikine-Iskut reservoirs. The results of this study are contained in Schultz-FTN (1983; 1984a, b). The temperature of water computed using the reservoir model was then routed downstream by Hydraulics Department, B.C. Hydro, using the model "WATSIM" to compute mainstem water temperatures from the powerhouse to the Stikine estuary, the results of which are presented in B.C. Hydro (1984b).

MANAGER was used to address the major questions regarding the impact of hydroelectric development on water quality. The model simulates the dynamics of over 20 water quality variables including major physical, chemical and biological factors. The sparse nature of input data used to calibrate and run the model suggests that results to date are preliminary and verification through further study is warranted.

(i) Studies Carried Out for B.C. Hydro

In the fall of 1978, Schultz International Ltd. were requested by B.C. Hydro to provide a review and assessment of the state of knowledge pertaining to the physical environments and biological components of the Stikine estuary. Following completion of this work (Schultz, 1979), Beak Consultants Ltd. were contracted to assess the potential impacts development would have on the floodplain and Stikine estuary.

Limited field studies were conducted in the estuary in late 1979 and early 1980 and summarized in Beak (1981, 1982). Because the understanding of the physical environment was too limited to make realistic predictions of biological impacts arising from regulation, field studies in 1981 concentrated on physical processes occurring in the estuary. The major components of this field program were:

1. measurements of salinity distribution at high tide throughout the estuary at various river discharges;

2. measurements of suspended sediment concentrations at the USGS gauge and north arm/south arm bifurcation;

3. measurements of meteorological parameters over the winter of 1980/81;

4. bathymetric survey of the delta front; and

5. surveying a test reach comprised of four cross-sections on the floodplain of the Stikine River.

Data collected during this field program are presented in Beak (1982) together with a preliminary analysis of changes in the physical environment which would occur following regulation of the Stikine and Iskut rivers.

In the spring of 1983, a field program was conducted by IEC-Beak Consultants to define the natural hydrological characteristics of the Estuary test reach in Alaska. The major objectives of the program were:

1. to establish stage-discharge relationships for each of the four surveyed cross-sections in the Estuary test reach;
2. to determine the relationship between water levels in the Stikine River mainstem and water levels in selected side channels and sloughs adjacent to the river; and
3. to record maximum water levels at selected floodplain sites used by anadromous fish.

Results of this field program are contained in a data report (IEC-Beak, 1984).

(ii) Independent Water Resource Studies

The earliest hydrological work in the Stikine basin was probably initiated by the Water Survey of Canada with the installation of the first hydrometric station at Telegraph Creek in 1954. This was followed by installation of the stations Stikine River above Grand Canyon in 1957 and Iskut River below Johnson River in 1959. In subsequent years other stations were installed on the Stikine and Iskut rivers or their tributaries. The primary purpose of these stations was the measurement of natural discharge in the Stikine basin. The location of all hydrometric stations is shown in Fig. 5-2.

The Water Survey of Canada has continued to maintain and operate these hydrometric stations in the Stikine basin, expanding the data collection in 1980 to include daily sampling of suspended sediment concentrations at Stikine River above Grand Canyon. Beginning in 1978, the collection of hydrometric data was further expanded, in cooperation with B.C. Hydro, to include continuous measurements of water temperature and periodic measurements of suspended sediment concentrations and water quality.

Inland Waters Directorate, Pacific and Yukon Region, Water Quality Branch of Environment Canada, have been independently conducting specific water quality studies within the Stikine and Iskut river systems but the majority of results have not yet been published. Their work centres on the lower reaches of both rivers in the vicinity of the international border. Parameters being investigated have included nutrients (carbon, nitrogen and phosphorus species), microbial communities, sediments, clay typing and metals. Further study by the Branch is planned, however, the sampling frequency is now very infrequent.

The collection of daily discharge data on the lower Stikine River in Alaska was initiated by the U.S. Geological Survey in July 1976 with periodic water quality samples beginning in October 1975. Data for Stikine River near Wrangell has been published annually by the USGS in the Water Data Report for Alaska. In 1982, daily measurements of suspended sediment concentration, funded by B.C. Hydro, were obtained by the USGS at Stikine River near Wrangell. The USGS continues to obtain daily measurements of discharge and periodic water quality samples as part of a long-term data collection program although monitoring of water temperature was discontinued in August 1981.

With the formation of the Stikine-Iskut Task Force in 1981, U.S. Federal and State government agencies identified a number of concerns regarding possible changes in the physical environment in Alaska which could occur following regulation. The U.S. Forest Service and U.S. National Marine Fisheries Service initiated a hydrological field program in 1982 which was continued during 1983. The main objectives of this program were:

1. to determine the range of mainstem discharges which affect hydrological conditions in side channels and sloughs;

2. to establish relationships between mainstem river discharge and wetted area for water depths less than about 1 m (3 1/2 ft) in side channels and sloughs; and

3. to establish a number of reference points throughout the floodplain in Alaska at which measurements of stage could be obtained in conjunction with sampling of juvenile rearing salmonids.

This program complements the field program conducted by IEC-Beak in 1983 on the Stikine floodplain in Alaska.

(b) Resource Summary

(i) Present Hydrological Resources of the Stikine-Iskut Rivers

The Stikine River and its major tributary, the Iskut River, drains a large area of northern British Columbia before flowing through Alaska to the Pacific Ocean near Wrangell (Fig. 5-2). The pristine watershed of the Stikine River is about the fifth largest in British Columbia in terms of basin area and mean annual discharge at the mouth. The Stikine River drains a total area of 51 600 km², of which approximately 1850 km² (3.6 percent) is in Alaska. The mean annual discharge at the mouth for the period 1977 to 1982 is 1621 m³/s (57 245 cfs), equivalent to a runoff of approximately 990 mm/a over the entire basin. The mean annual discharge of the Stikine River at the proposed Stikine Canyon damsite is about 299 m³/s (490 mm/a) while at the Iskut Canyon damsite, the mean annual discharge is about 280 m³/s, equivalent to a runoff of 1225 mm/a.

The discharge of the Stikine River exhibits a high degree of natural variability at all time scales between an hour and a year or more. For the gauging station Stikine River near Wrangell, the extreme flow recorded (1977 to 1983) was 8480 m³/s while the minimum recorded discharge was 127 m³/s. The annual range of mean daily discharge at other locations on the Stikine River may vary by a factor of 100 or more while on the Iskut River mean daily discharge may vary by a factor of 200 or more during the year. On the lower Stikine and Iskut rivers, mean daily discharge may vary by as much as 300 percent from one day to the next. Large hourly fluctuations in discharge and stage have also been recorded which is discussed in more detail in Jones (1984).

The Stikine and Iskut rivers are predominantly alluvial, gravel bed rivers downstream of the proposed damsites except where locally confined by bedrock. River morphology varies from entrenched, single thread channels to laterally unstable multiple channels with islands and braided reaches.

River gradients vary from less than 0.005 to more than 0.006 where falls and high velocity water immediately downstream of the proposed damsites create barriers to the upstream migration of anadromous fish on both the Stikine and Iskut rivers. Many of the tributaries, except for the larger rivers, have high gradients and are only accessible to anadromous fish for short distances upstream from the confluence with the Stikine and Iskut rivers.

Due to the northern latitude, water temperatures are low. Maximum summer water temperatures on the Stikine and Iskut rivers occur near the headwaters and progressively decrease downstream due to discharge originating from glacial melt. The maximum recorded water temperature at Telegraph Creek is 14°C compared with a recorded maximum temperature of 11°C at Stikine River near Wrangell. The maximum recorded daily water temperature on the lower Iskut River is 10°C (B.C. Hydro, 1982a). In the winter, water temperatures decline to 0°C for extended periods, allowing the formation of anchor ice and surface ice cover over most of the Stikine and Iskut River channels except for local areas which tend to remain ice free during most winters.

At the mouth of the Stikine River, a large delta has developed due to the deposition of sediment transported by the river. The total surface area of the delta (between the north and south arms of the Stikine River and the edge of the intertidal zone, excluding islands) is approximately 200 km^2 (Beak, 1982). The long-term annual suspended sediment budget of the Stikine estuary is estimated to be 21.37 Mt of which about 31 percent is contributed by the Iskut River and the remainder by the Stikine River (B.C. Hydro, 1982b).

(ii) Potential Changes in the Physical Environment With No Development

A. Hydrology

The discharge of the Stikine and Iskut rivers is affected primarily by the annual precipitation and mass balance of glaciers in the Stikine and Iskut basins, both of which are difficult to predict. The evidence for long-term trends in precipitation and hence river discharge is ambiguous and difficult to interpret because of the short duration of historical records. However, an analysis of precipitation and discharge records for British Columbia (Schaefer, 1975, 1976; Barrett, 1979; Jones, 1984) suggests that aperiodic changes in precipitation and discharge do occur. Short historical records and lack of a theoretical explanation for such changes limits our ability to make reliable projections regarding future hydrological conditions on the Stikine River. It is equally possible for a continuation of present conditions or for either an increase or decrease in mean annual discharge and annual maximum flood peaks. Recognizing the uncertainty of any projections, the best that can be assumed is that hydrological conditions will remain similar to the present conditions during the next 2 to 3 decades.

The long-term precipitation and discharge of the Stikine and Iskut rivers is also likely to be affected by increasing levels of CO_2 in the atmosphere. Although there is some dispute over the magnitude of the warming to be expected, the emerging consensus is that, other factors remaining constant, the earth, and high latitudes in particular, will warm significantly in response to increasing CO_2 levels. The effect on the hydrologic cycle is only beginning to be appreciated, and may be responsible for recent changes in precipitation and runoff in the United States (Foster and Sewell, 1981). If climatic changes due to increased CO_2 levels lead to increased temperatures, then discharge may increase in the short-term due to glacier melting. In the longer term, however, the limited volume of water stored in glaciers would result in a reduction of annual discharge unless the changes are offset by increased annual precipitation.

B. Sediment Transport

The transport of suspended sediment and to a lesser extent sediment transported as bedload is supply limited and it is difficult to assess changes in sediment supply originating from glacier recession which has occurred during the last 50 years or more. Estimates of annual sediment deposition in the Stikine estuary derived from comparison of data obtained in hydrographic surveys in 1887, 1954, 1961, 1976 and 1981 (Beak, 1982) provide insufficient accuracy and resolution to determine if there has been any long-term trends in sediment transport. Barring a change in local climate leading to a change in the mean annual discharge and magnitude of flood events, there would appear to be little basis for assuming there will be any change in sediment transport or the annual sediment budget of the Stikine estuary in the foreseeable future.

C. River Morphology

Other than where the rivers are single channel and partially confined, it is difficult to predict, except in a general, qualitative manner, the future morphology of the Stikine and Iskut rivers. The primary factors which result in a large uncertainty in the predictions of the future morphology are:

1. lack of theoretical, quantitative models for some of the processes involved;
2. inability to predict future precipitation, discharge and, to a lesser extent, sediment supply; and
3. inability to determine either the relaxation time between changes in discharge and morphological response or whether the present channel form is fully adjusted to the hydrological regime.

During the period 1949 to 1983, numerous local changes in channel morphology have occurred on both the Stikine and Iskut rivers, but the general pattern has remained the same (Jones, 1984). In some reaches there appears to have been a gradual increase in the number of secondary channels on the floodplain. In the future, the Stikine and Iskut river may either increase or decrease the number of secondary channels on the floodplain by erosion, transport and deposition of sediment while maintaining the present general river morphology. The number of secondary channels on the floodplain in some reaches could vary naturally by 10 to 20 percent over the next 2 to 3 decades.

The morphological changes which have occurred during the last 30 years where the Stikine River splits into the north and south arms in the vicinity of Limb Island indicates the complex processes and difficulty of predicting future conditions. Since 1949, the Stikine River has deposited large volumes of sediment immediately upstream of Limb Island where the river begins to flow into the north arm. Further downstream the Stikine River has eroded a large portion of Limb Island to the extent that the island is nearly cut in two. If the river continues to erode Limb Island, the upstream channel supplying the north arm may be abandoned with discharge being conveyed by the cutoff, bypassing the entrance to the north arm. This would diminish discharge and sediment delivery to the north arm of the estuary. However, neither the occurrence nor timing of such a change can be predicted.

D. Stikine Estuary

The future growth and morphology of the Stikine estuary is a function of several factors which are, in order of relative importance:

1. rate of sediment delivery to the Stikine estuary;
2. local bathymetry of Eastern Passage and width of active delta front;
3. rate of local isostatic rebound which affects the gradient of the lower Stikine River; and
4. relative distribution of flow and sediment delivered to the north and south arms of the estuary.

Based upon historical data obtained from hydrographic surveys and aerial photography (Beak, 1982), the Stikine estuary, particularly the south arm, has advanced seaward, and the process may be expected to continue in the foreseeable future. The north arm of the Stikine estuary appears to be growing slowly, if at all (Beak, 1982). Insufficient data are available to accurately assess conditions in the Stikine River, but historical changes in morphology suggest that discharge and sediment transport through the north arm are decreasing. Assuming that erosional and depositional processes are roughly balanced, the north arm flats of the Stikine estuary will probably remain stable in the foreseeable future, although continued isostatic rebound in the order of 1 cm/a (Vanicek and Nagy, 1980) is likely to affect discharge and sediment transport to the area. As noted previously, changes, particularly a reduction in the annual sediment budget of the Stikine estuary, are not foreseen in the near future, although it is conceivable that the annual sediment budget could increase slightly if logging, mining and other developments were to occur in the Stikine basin.

E. Water Temperature

No changes in the water temperature of mainstem and floodplain areas of the Stikine and Iskut rivers are likely in the foreseeable future barring major shifts in the local and regional climate. The temperature of surface water in the winter is 0°C which would require a dramatic moderation of winter climate to effect changes in water temperature which is highly unlikely. In the summer, mainstem water temperatures downstream of the proposed damsites are heavily influenced by the volume of water originating from snow and glacier melt. Summer water temperatures will continue to show a trend towards lower values in the lower reaches of the Stikine and Iskut rivers as well as considerable variability but the general pattern can be expected to remain similar to present conditions described in B.C. Hydro (1984(b)).

F. Water Quality

Paucity of data and insufficiency of studies limit the description of the water quality in the Stikine and Iskut rivers. Table 5-8 presents maximum and minimum values of over 30 parameters for four sites having the greatest frequency of sampling.

The waters range from soft to moderately soft, typical of drainage from igneous rocks. Marked seasonal variations of turbidity and suspended sediment prevail and the major sources of sediment are glacial tills of granitic and volcanic composition. Over the annual cycle the rivers appear to transport limited nutrients in the form of nitrogen and phosphorus; however, export of carbon from terrestrial sources may be a significant factor. The concentration of heavy metals through mobilization and transportation processes associated with sediments seems to be low and would be expected due to the neutral to alkaline nature of the waters. There is only one water licence for the Stikine River. This user is located in Telegraph Creek and extracts 1000 gallons per day for domestic use. There are no licences for the Iskut River and there are no well records for either the Stikine or Iskut rivers relating to groundwater use.

Considering the remote and relatively pristine nature of the watersheds with isolated and low man-made inputs, the concentration of elements appear well within the environmental range of other major provincial and federal surface waters. Water quality does not currently limit existing water uses.

(c) Expected Impacts

(i) Hydrology

Construction and Reservoir Filling

Changes in hydrological conditions downstream of each project would be negligible during construction; a period when a diversion tunnel(s) is used to pass discharge around the construction site. Upon completion of each dam, the diversion tunnel(s) would be closed, temporarily interrupting downstream flow and allowing water to fill the reservoir behind the dam. Once water levels reach the elevation of the low level outlets, the continuity of flow would be restored. At Stikine Canyon, the duration of flow interruption would vary from less than 1 hour if reservoir inflows are high to almost 20 hours if diversion closure occurred late in the year when river discharge is low (Jones, 1984). At Iskut Canyon, low level outlets would be operational prior to closing the north diversion tunnel. Some reduction in flow would occur until the reservoir level increased sufficiently to pass the inflow through the low level outlet.

For More Creek reservoir, it is proposed to release no flow until operational levels have been reached during initial reservoir filling, thus dewatering approximately 1.0 km of More Creek between the dam and the confluence with the Iskut River during the filling period.

Once downstream flow from low level outlets is resumed, it is proposed to release a discharge equal to 10 percent of the mean annual discharge at the damsite for the winter months through to the end of April. The release of 10 percent of the mean annual discharge would ensure that flows downstream from the reservoir would not generally decline below historically recorded levels (Jones, 1984).

After 1 May, it is proposed to increase reservoir discharge to 30 percent of the mean annual discharge at the damsite during initial filling. For the filling of the Stikine Canyon reservoir, mean monthly summer flows at Telegraph Creek would be reduced between 50 and 75 percent while at the mouth, mean monthly discharge would be reduced between 15 and 30 percent. During initial filling of More Creek and Iskut Canyon reservoirs, mean monthly summer discharges on the lower Iskut River would be reduced between 10 to 30 percent with a reduction of between 5 to 15 percent on the Stikine River near Wrangell. More detailed information along with annual hydrographs for the period 1977 to 1981 for filling of each reservoir can be found in Jones (1984).

Regulated Hydrology

Construction and operation of the combined Stikine-Iskut projects would regulate approximately 35 percent of the mean annual discharge of the Stikine River at the mouth. The seasonal distribution of flows would be altered so that mean monthly discharge during the winter at Telegraph Creek would be 4 to 7 times higher than natural conditions and 2 to 4 times higher than natural conditions at Stikine River near Wrangell. Mean monthly discharge at Telegraph Creek during the summer would be reduced between 2 to 4 times, while at Stikine River near Wrangell, the mean monthly summer discharge would be reduced between 1.1 to 1.5 times by the two projects (Jones, 1984).

Because of powerflows, minimum mean daily discharge during the winter would be up to 3 times larger than naturally occurring minimum flows. In particularly dry years such as 1978, mean daily discharge during annual refilling of the reservoirs could result in very low discharges downstream of the powerhouses. In particular, minimum mean daily discharge at Telegraph Creek during June, July and August could be 3 times lower than recorded flows during these months (Jones, 1984). Besides the possibility of very reduced summer discharge, the frequency of flows less than 300 m^3/s at Telegraph Creek would be increased about eight-fold.

Annual hydrographs for the period 1977 to 1981 showing natural, reservoir filling and normal operational conditions (Jones, 1984) indicate that the rising limb of the spring hydrograph would be delayed up to 2 weeks due to the annual refilling of the reservoirs. The hydrographs also show that the magnitude and timing of flood peaks, particularly in the summer, would be affected by regulation. Floods at Telegraph Creek with a 2-year recurrence interval would be reduced about 57 percent while at Stikine River near Wrangell, the combined projects would reduce the flood having a 2-year recurrence interval by about 17 percent in the spring-summer and about 5 percent in the fall (Jones, 1984).

Based upon analyses of natural fluctuations in stage for the months May through October 1979 to 1981, Jones, (1984) found that 98 percent of all changes in decreasing stage were less than 25 mm/h at Stikine River above Butterfly Creek. Locations further downstream on the Stikine River and lower Iskut River exhibited a slightly higher natural variability.

Estimated powerflows from Tanzilla and Iskut Canyon were routed downstream to the estuary to provide estimates of the probable maximum rate of change on declining stage which might occur due to normal power operation. Regulation would impose a higher frequency of large rates of declining (and increasing) stage/discharge than would otherwise occur naturally.

(ii) Sediment Transport Impacts

The Stikine and Iskut reservoirs would trap all bedload and a large fraction of the total suspended sediment load delivered to the damsites. Because computed reservoir trap efficiencies vary from 100 percent for More Creek reservoir to 87 to 93 percent for Iskut Canyon reservoir (Jones, 1984), a fraction of the fine silts and clays would pass through the reservoirs in suspension, particularly during periods of spill.

Based upon estimated annual suspended sediment loads for the period 1978 to 1982, the annual suspended sediment budget of the Stikine estuary would be reduced between 27 to 43 percent with a long-term average reduction of 31 percent (Jones, 1984). Bedload transport is estimated to be about 5 percent (maximum less than 10 percent) of the annual suspended sediment load and probably would be reduced about 30 percent following regulation. The percent composition of clay, silt and sand delivered to the estuary is expected to remain comparable to natural conditions with relative increases in silt and clay of less than 2 percent.

(iii) River Morphology

The lack of theoretical, quantitative models and impractical data requirements limits our ability to quantify the magnitude of morphological changes in alluvial rivers arising from regulation (Kellerhals, 1982). The general changes in river morphology following regulation of the Stikine and Iskut rivers are:

1. abandonment of secondary channels which are flooded infrequently for short duration;

2. gradual deposition of fine sediments and organic material in secondary channels followed by the gradual encroachment of vegetation;

3. increased lateral stability of the river reduces the rate at which new secondary channels are created at the same time that other channels are being lost; and

4. short-term degradation and incision of alluvial fans at the confluence of tributaries in response to reduced base levels followed by progradation of the tributary fan into the mainstem.

While channel pattern has remained relatively constant, the Stikine and Iskut rivers have exhibited a high natural variability in the number of secondary channels. Jones, (1984) provides evidence which suggests that the length of secondary channels in some individual reaches downstream of the proposed damsites has varied by 20 percent or more over a 30-year period.

Regulation would affect morphology of the Stikine and Iskut rivers from the reservoirs downstream to the Stikine estuary. Jones (1984) discusses the natural and regulated morphology on a reach-by-reach basis. Based upon analogy with other regulated rivers, analyses of aerial photography and professional judgement, the probable percent reduction in length of secondary channels has been estimated for each reach. The probable reduction in the length of secondary side channels on the Stikine River is estimated to vary from 40 percent in the vicinity of the Chutine River to less than 5 percent on the lower Stikine River in Alaska. Because regulation of the Iskut River would probably result in a large reduction in sediment supply compared with the reduction in the magnitude of the flood peaks, the reach upstream of Hoodoo River would probably change to a single thread channel. Depending upon the depth that the Iskut River incises its channel, it is possible that between 50 to 100 percent of the secondary channels could be abandoned upstream of the confluence with the Hoodoo River. Downstream of the confluence with the Hoodoo River it is estimated that between 10 to 30 percent of the secondary side channels could be abandoned following regulation (Jones, 1984).

The large reduction in discharge and sediment supply in Forrest Kerr Creek which would occur following diversion of Forrest Kerr Creek into More Creek would result in a tendency for Forest Kerr Creek to shift from a highly braided pattern towards a more stable, single channel morphology. The reduced flows, however, are unlikely to be capable of transporting the large bed materials. As a result, the creek would be constrained by rigid boundaries and thus confined to major channels present at the time of diversion.

(iv) Regulated Water Temperatures

Since reservoirs store heat energy, downstream water temperatures would be generally cooler in summer and warmer in winter with most changes contributed by Stikine Canyon and Iskut

Canyon reservoirs. Using the reservoir model "MANAGER", Schultz-FTN (1983, 1984a) estimated that water temperatures of power flows from Stikine Canyon reservoir would deviate from natural conditions by 5°C in summer and 4° to 6°C in winter. At Iskut Canyon, summer water temperatures would be decreased between 0° and 2°C compared with natural temperatures of 5° to 9°C and increased between 2.5° and 4°C in winter. A preliminary study of selective withdrawal facilities found that regulated winter outflow temperatures could be reduced between 0.5° and 1.0°C at Stikine Canyon and Iskut Canyon reservoirs (Schultz-FTN, 1984b). Preliminary data indicate that the natural temperature regime, could not be duplicated using selective withdrawal facilities.

Using the water temperature model "WATSIM" to route powerflows downstream, it is estimated that the Stikine mainstem water temperature in winter may reach 4°C at Tanzilla and decline to near 0°C at some point between the Chutine and Iskut rivers, depending upon weather conditions. Water temperatures would remain at or near 0°C throughout the remainder of the Stikine River. Mid-winter temperatures in the Iskut River would vary from about 4°C near the Iskut Canyon powerhouse to about 1°C near the Stikine River confluence. Water temperatures would only rarely reach 0°C in extreme cold winters in the lowest reaches of the Iskut River. Consequently, the mainstem Stikine River would probably remain ice free from Tanzilla downstream to the vicinity of the Stikine-Iskut confluence under most conditions while the Iskut mainstem would be rarely ice covered. Secondary channels downstream of the powerhouses which are not connected by surface discharge to the mainstem would be expected to remain ice covered during the winter. The increase in winter water temperatures should eliminate the formation of anchor ice which has been observed on several occasions in large quantities in the mainstem Stikine and Iskut rivers (B.C. Hydro, 1984b).

Under natural conditions, mid-summer water temperatures in the upper reaches of the Stikine River at Telegraph Creek may be between 4° and 6°C higher than in reaches near the mouth of the river. Cooler water released from the Stikine Canyon reservoir would tend to reduce this difference and dampen the natural variation of annual summer maximum water temperatures. Summer water temperatures at Telegraph Creek for regulated conditions would be 2° to 4°C lower than natural conditions. Deviations from natural conditions downstream would be less because after regulation, the temperature differences between mainstem and tributary flows would be smaller. Above the Iskut confluence, the regulated water temperature would be about 1°C below the natural regime.

Because of the relatively small volume of the Iskut Canyon reservoir compared with total summer inflow, temperatures in the reservoir would tend to follow the natural regime, although with some delay. As a result, in the period June through August, maximum deviations of 1°C above or below natural water temperatures may occur. In the lower Stikine River downstream of the Iskut River, maximum deviations from the natural regime would generally be less than 0.5°C (B.C. Hydro, 1984b).

(v) Stikine Estuary

Regulation of the Stikine and Iskut rivers would increase winter flows (December to March) at the mouth up to 4 times and reduce spring and summer flows (May to August) up to 1.5 times while fall flows (September to November) would be largely unchanged (Jones, 1984). The seasonal redistribution of freshwater discharge would alter the nearshore salinity regime; the intrusion of the salt wedge during the winter would penetrate about 0.6 km less than existing conditions while the salt wedge would penetrate about 1.8 km further inshore during the naturally high runoff conditions in the summer (Beak, 1982).

The eastern portion of the south arm of the Stikine estuary has advanced rapidly during the last 30 years or more and it is probable that this portion of the estuary would continue to grow, albeit, at a reduced rate following regulation of the Stikine and Iskut rivers. The rest of the estuary appears to be relatively stable with the exception of the western portion of the south arm near Sergief Island which shows signs of retreating (Beak, 1982). Beak tentatively concluded that the estuary would remain stable, although the western portion of the south arm is most at risk to erosion following regulation. However, the ultimate fate of the Stikine estuary, except for the eastern portion of the south arm, cannot be predicted reliably because of insufficient data and knowledge of erosional and depositional processes affecting estuarine morphology.

Following regulation, the water temperature of the Stikine River at the mouth is estimated to differ by less than 1°C from natural conditions compared with an annual range between 0° to 10°C (B.C. Hydro, 1984b). Freshwater discharge would be rapidly mixed with large tidal volumes of marine water further reducing the effects of any temperature changes.

(vi) Water Quality Effects

The creation of reservoirs with the subsequent flooding of valleys would result in change to the water quality of those regions. During inundation there would be some short-term localized degradation of waters covering newly flooded areas and at depth mainly due to erosion and solubilization of terrestrial materials. Dilution due to storage, and reduction in velocity due to increased residence time behind the dams should tend to maintain the overall water quality within acceptable ranges.

Construction-related impacts such as siltation from dam construction would be expected to be short-term and the effects would be minimized by adherence to standard construction practices. All permit requirements for waste management will be met.

Nutrient leaching and solubilization may increase productivity within the reservoirs for 2 to 4 years after inundation and result in an increased dissolved and total organic carbon export downstream in the range between 4 and 6 mg/L. There would likely be a higher release of organic detritus for downstream communities from the Iskut system than the reservoir series of the Stikine. The Iskut reservoir would have the highest productivity while Tanzilla would have the lowest, although all reservoirs are likely to be oligotrophic. The concentration of nitrates would increase in the hypolimnion of the reservoirs but high flushing rates and dilution would ameliorate this increase to acceptable levels.

Nutrient leaching and anoxic conditions at the bottom of reservoirs may result in release of some heavy metals, including mercury. However, soil tests have indicated low amounts of heavy metal substrate in reservoir areas and natural drainage waters are currently found to be low in these type of elements. This combined with the fact that the water in these reservoirs will have a short residence time, and near neutral pH suggests that heavy metal concentrations in these reservoirs will not be a water quality problem.

During spilling, the levels of dissolved gas supersaturation immediately downstream would be less than 120 percent, and when fully mixed with powerplant flows, probably less than 110 percent. Further reductions are expected downstream as a result of tributary mixing and water turbulence.

(d) Conclusions

Based upon hydrological studies which have been completed several changes in the physical environment, the magnitudes of which are difficult to predict, may be of concern. These are:

1. Changes in the river morphology downstream of the projects is expected to reduce the total length of secondary channels.

2. The normal operation of the Stikine and Iskut projects as proposed, would impose more frequent and pronounced daily and hourly fluctuations in discharge.

3. Current studies suggest that the Stikine estuary would either remain stable or continue to grow at a reduced rate given a 31 percent reduction in the annual suspended sediment delivered to the estuary. More definitive predictions of the probable and worst case responses of the Stikine estuary are needed.

4. Data collected from this and other study areas suggest that water quality will remain high with the developments in place. No major impacts are expected, but additional information is required to clarify potentials for supersaturation, heavy metal release and changes to nutrient balances. Based on the

preliminary data, it is concluded that the development is feasible from a water quality viewpoint.

5.2.7 Aquatic Resources

(a) Summary of Studies Conducted

(i) Generation and Downstream Areas (Areas 1 and 2)

A. B.C. Hydro Studies

Studies conducted by B.C. Hydro on the fisheries and aquatic resources of the Canadian reaches of the Stikine and Iskut drainages began in 1977 with overveiw studies by J.R. Irvine (1977a, 1977b). These included limited fish sampling during September and October of 1977, and identified future information requirements. In particular, Irvine suggested studies of the effects of development on flow, sediment transport, temperature regime, and of life history and exploitation of salmon originating in the system and its tributaries.

In 1978 detailed fisheries studies were undertaken in areas within and above the proposed impoundments (Jones and Tsui, 1979) and in Canadian sections of the drainage below the proposed dams by Northern Natural Resource Services (NNRS, 1979).

Studies of aquatic resources of the lower (Alaskan) reaches of the Stikine and its estuary began with a background study of available knowledge by Shultz International Ltd. (Shultz, 1979).

Information accumulated during these studies was integrated during a one day workshop held in May 1979. The workshop involved B.C. Hydro, its consultants, representatives of provincial, state, and federal government agencies from Canada and the United States, as well as academics with related research interests. This workshop was used to identify problems in assessment of potential impacts associated with proposed developments, and suggested methods for their solution. Results of this workshop were taken into consideration in the preparation of terms of reference for feasibility studies of fish and aquatic habitat. Studies based on these terms of reference began in the fall of 1979. Between the U.S./Canadian border and proposed dam sites, salmon spawning and rearing areas and water quality were studied by Aquatic Environments Ltd. (McCart, 1980), while in the estuary, Beak Consultants Ltd. studied a variety of factors including juvenile fish distribution and water quality (Beak, 1981).

Detailed studies continued through 1980 and 1981 (AEL, Volume I, 1982 and Beak, 1982). Studies in 1982 and 1983 included an enumeration of salmon fry leaving the Tahltan River (AEL, 1982b), the distribution and abundance of chinook spawners (AEL, 1983b), eulachon spawning (IEC-Beak, 1983a), salmonid rearing in floodplain habitats in Alaska (IEC-Beak, 1983b), and finally, the development rates of Stikine salmon eggs and habitat characteristics of mainstem spawning and rearing areas (AEL, 1984).

B. Studies by Other Agencies

In addition to studies by B.C. Hydro and its consultants, the Alaska Department of Fish and Game (ADF&G) and the National Marine Fisheries Service (NMFS) have undertaken studies of the distribution, abundance and ecology of eulachon (Franzell and Nelson, 1981) and juvenile and adult salmon (ADF and b Unpuvlished Notes). The B.C. Department of Fish and Wildlife, Aquatic Studies Branch, recently completed a detailed inventory of the habitats of the Iskut River and some of its tributaries.

C. Resource Management

Primary responsibility for management of Stikine fisheries resources in Alaska rests with ADF&G. In Canada, the Department of Fisheries and Oceans (DFO) is responsible for managing salmon, while other species are the concern of B.C. Fish and Wildlife. ADF&G and DFO annually collect information on the escapement and harvest of salmon stocks in the area. Until the mid-1970s, ADF&G conducted regular aerial spawning surveys in both Canadian and Alaskan sections of the Stikine and Iskut rivers and their major tributaries, and operated a spawner counting fence on the Tahltan River. The counting fence was taken over by DFO personnel in 1975.

(ii) Transmission Areas (Areas 2 and 3)

Two studies were planned to assess the impacts on fisheries due to the transmission system for the development. The initial study was carried out by Sigma Environmental Consultants during 1980/81. Approximately 4600 km of candidate corridor were examined to provide information of fish species present, their distribution, habitat and use. The data on resource use were collected to record the location and extent of the local sport and native food fisheries. Effects of transmission line construction and operation were assessed (Sigma, 1982) and the results integrated and assembled in the comparative evaluation of corridor options (Hayward, 1982). This latter report was then used to select transmission corridors for further study.

The second study was directed towards determining a suitable transmission line route within the selected corridor(s) and evaluating the environmental impacts. This study was awarded to Aquatic Resources Ltd. in early 1983 and was just initiated when project deferment resulted in its cancellation.

For the the Interim Assessment Report a given route has been evaluated. B.C. Hydro biologists met during the fall of 1983 with representatives of the Federal Department of Fisheries and Oceans and the Fish and Wildlife Branch of the B.C. Ministry of Environment to obtain information on the fisheries resource along the entire transmission line route. This was followed by an aerial reconnaissance. Accordingly the assessment provided in this report draws heavily on the preliminary data from the Sigma report and especially on the information gained during the discussion and site visits of late 1983. The 1983 work concentrated on determining where important fish habitat exists for both anadromous and resident fish. Specific information on the extent, location and importance of food or sport fishing was not collected during 1983.

(b) Resource Summary

(i) Generation and Downstream Areas

A. Overview of Stikine-Iskut Fisheries

A variety of fin and shellfish are permanent or occasional residents of the Stikine and Iskut rivers and the Stikine estuary. Many species support important commercial, subsistence or recreational harvests. Table 5-9 lists the common and scientific names of fish and shellfish within the Stikine drainage and its estuary. Figs. 5-5A and 5-5B provides the locations of major spawning and rearing areas for anadromous fishes on the Stikine and Iskut rivers.

Commercial Harvest

Five species of Pacific salmon (sockeye, chinook, coho, chum and pink) are intercepted in commercial harvests in marine waters of southeast Alaska. Significant commercial harvest of Stikine River stocks probably coincided with or preceded construction of the first salmon cannery near the mouth of the Stikine in 1887. In 1886 a harvest of 64 000 fish including 4000 chinook, 30 000 coho and 30 000 sockeye was recorded (Rich and Ball, 1933). While Rich and Ball present catch statistics from 1885, Richardson and Johnston (1966) describe as reliable only those data collected after 1938.

Following a peak catch of over 80 000 sockeye in 1941, the catch declined to an average of 20 000 pieces annually in the 50s and has since remained fairly constant.

Recently, chinook and coho catches have declined dramatically, and during the 1970s were only 25.2 percent and 29.8 percent of their respective catches in the 1950s (AEL, 1982). Declines in chum salmon catches have been similar (22.3 percent of 1950s average) except for a single large catch in 1977. Catches of pink salmon peaked in the 1960s at an annual average of 41 000 pieces and have declined to an average of 10 000 pieces during the 1970s. AEL (1982) presents the annual commercial catch of salmon in Alaska from 1951 to 1982.

Commercial gillnetting in Canadian waters of the Stikine began with exploratory fishing in 1965 (Crouter and Todd, 1965). Commercial test fishing began in 1975 and has increased in importance. Between 1975 and 1978 the catch averaged 10 percent of the total gillnet harvest, and increased to 58.8 and 47.8 percent in 1978 and 1980. Canadian commercial catches are presented by AEL (1982).

It should be noted that troll and seine harvests are not included in these data because the origin of these fish cannot be readily determined. However, including allocations of seine- and troll-caught salmon to the Stikine results in an estimated 22.7 percent of total Stikine salmon harvest being taken in the Canadian Fishery in 1979 and 1980. A detailed report addressing the partitioning of transboundary stocks in the Stikine has been prepared by M.P. Shepard and included as Appendix A in AEL Volume III (1982).

Domestic Fishery

No routine large-scale subsistence fishing occurs on the Stikine River in Alaska. The major native fisheries for

Stikine salmon take place on the river between Dodjatinan Creek and the Tahltan River, and on the Tahltan near its confluence with the Stikine. During the 1940s approximately 8000 sockeye were taken annually (Richardson and Johnston, 1966). Catches have declined both because of reduced salmon abundance and a greatly reduced demand for sled dog feed. From 1975 to 1980 annual domestic catches averaged 1150 chinook and 3000 sockeye (AEL, 1982). Pink and chum salmon are rarely taken as far upstream as Telegraph Creek.

Sports Fishery

Relatively little information is available quantifying the recreational harvest of salmon and steelhead. Salt water recreational fisheries are concentrated near Wrangell and Petersburg. Some creel census information is available from the Alaska Department of Fish and Game (ADF&G) and Department of Fisheries and Oceans (DFO) but had not been received at the time of writing. In any event, it is difficult to determine the river of origin for these fish. A sport fishery for chinook and steelhead is concentrated near the Tahltan River bridge. In 1975 the recreational chinook harvest was estimated at 100 fish (NNRS, 1979). No estimate of steelhead harvest is available.

Cutthroat trout and Dolly Varden are taken in clear-water sloughs, creeks and tributaries in Alaska, and the former are also taken from tributaries near Telegraph Creek. Again, this harvest is probably not large, but no estimates of the numbers of fish are available.

Shellfish

Shellfish are taken in commercial and recreational harvests in the Stikine estuary outside the delta flats. Dungeness, tanner and king crab, stripe, spot and pink shrimp and prawns are taken in various pot and trawl fisheries. Between 1969 and 1976 the harvest of crab averaged 29 000 kg and shrimp 58 000 kg (Shultz, 1979). The Alaskan surf clam, butter clam and little neck clam support a recreational harvest in the Wrangell area, however, no data are available on the quantities taken.

Groundfish Fishery

Groundfish are harvested periodically from the delta drop-off near Wrangell. Between November 1978 and January 1979 approximately 544 300 kg were taken, 80 percent of which were starry flounders. This probably greatly exceeded the sustainable yield, and the harvest was subsequently curtailed. A small harvest is planned for 1984 (R. Timothy, ADF&G, pers. comm.).

Eulachon Fishery

Eulachon spawn in large numbers in the lower Stikine in early spring. Stikine eulachon are not harvested by native Indians but do support a recreational fishery. Eagles, seals, sea lions and seagulls congregate at the mouth of the Stikine during the eulachon run in late March through early May. It is likely that eulachon, with high fat content, are an important food source for these animals. Eulachon larvae and fry may also contribute significantly to the diet of juvenile salmon and starry flounders rearing in the estuary and near-shore areas.

B. Biology of Stikine-Iskut Fish

Salmon

Salmon are distributed as far upstream as the Stikine and Iskut canyons, which constitute barriers to further migration. Many tributaries are also impassable to fish near their confluence with the Stikine. The Chutine and Tahltan rivers are notable exceptions (NNRS, 1979).

Chinook

Stikine chinook salmon usually mature in their fourth (28 percent) and fifth (65 percent) year, enter the river in April and May, and migrate upriver through June and July. Spawning generally takes place from mid-July to mid-August.

Chinook spawning grounds are distributed widely throughout the drainage. Bergmann (1978) summarized available information and concluded that the Tahltan River and its tributaries support over 60 percent of the average annual Stikine escapement of 4140 adults. Spawning is known to occur in Andrew Creek and Yehiniko Creek (NNRS, 1979), and surveys of fry abundance strongly suggest spawning in the lower Tuya, Shakes Creek, Pendant Creek (tributary to the Chutine) and Christina Creek (Jones and Tsui, 1979).

Poor visibility hampers assessment of mainstem spawning in both the Stikine and Iskut rivers. Bergmann (1978) allocated about 25 percent of total Stikine chinook escapement to mainstem spawning areas and a further 12 percent to the Iskut and its tributaries. This estimate represents a best guess at the relative distribution of those fish remaining after known Stikine tributary spawning (especially the Tahltan) is subtracted from the estimated total escapement. Because both the numbers of tributary spawners and total escapement are subject to considerable error, these allocations serve as very rough estimates only.

NNRS (1979) found some evidence of chinook spawning in the Stikine mainstem, including redds near the mouth of Kunishma Creek and on a gravel bar near Glenora. NNRS (1979) also refer to DFO sources which report spawning in three mainstem areas: downstream of Donnaker Creek, opposite the mouth of Duker Creek and 3 km upstream of the Katete River.

In 1982 studies, AEL attempted to locate mainstem chinook spawners without success and concluded that few, if any, chinook spawn upstream of the Chutine River, which is the reach of the Stikine River likely to experience the greatest effects of the Stikine hydroelectric projects (AEL, 1983b).

Juvenile chinook in tributaries to the Stikine River emerge from the gravel in April and May and rear in slow shallow areas along the margins of the Stikine mainstem and in side-channels (NNRS, 1979, Jones and Tsui, 1979, AEL, 1982, Beak, 1982 and 1983, NMFS (unpublished)). Some rearing also occurs along the margins of larger tributaries. Emergent chinook fry prefer shallow slack water along stream margins, but as they grow and can tolerate faster currents, they move into deeper areas.

Diet analysis (AEL, 1982, Volume I; 1984) indicates that terrestrial insects constitute a major portion of juvenile chinook diet.

In many systems a substantial proportion of chinook fry migrate to the estuary during their first summer (so-called "90-day" fry) to rear for a period of several weeks or more before going to sea. This is a very rare occurrence in the Stikine. Scale analysis on adult chinook from the Stikine indicates that very few migrate to sea in their first year. These data support marsh channel seine data (Beak, 1982) which showed very few chinook rearing in the estuary. The majority of Stikine chinook spend 1 year in fresh water prior to seaward migration.

While little is known of juvenile chinook overwintering habitat, it is likely they remain in the mainstem in areas of deep, relatively slow water.

Sockeye

Sockeye in the Stikine basin are of two major types, Tahltan River/Lake type and main river spawning type. Tahltan River/Lake sockeye mature between their third and sixth year and enter the Stikine River in early June. The peak of the spawning run passes Telegraph Creek in mid-July and enters Tahltan Lake in mid-August. Peak spawning occurs in the Tahltan in late August or early September (AEL, 1982a) while sockeye spawning along the margin of the Stikine River occurs slightly later.

Main river spawning sockeye are widely distributed throughout the Stikine watershed. Surveys conducted in

1978 (NNRS, 1979) located and mapped numerous spawning areas in side-channels, sloughs and tributaries of both the Stikine and Iskut rivers. AEL (1982a) found sockeye in some of the same areas and captured sockeye as far upstream as Meehaus Creek on the Stikine and above Snippaker Creek on the Iskut River.

Sockeye spawners appeared to be more numerous and widely distributed in 1983 than they were in 1982 (AEL, 1984). During the 1983 surveys, 770 sockeye salmon (including four carcasses) and 80 redds (spawning nests) were recorded at 19 sites along the Stikine River. These figures compare with 174 sockeye salmon and 44 redds observed at 11 sites in 1982. Ten of the sites observed in 1983 were not previously reported as sockeye spawning locations.

Bergmann (1978) estimated that up to 90 percent of sockeye spawning in Canadian sections of the Stikine occurs within the Tahltan drainage. Since a counting weir was established in 1959, escapement has averaged 17 000 fish. This system may be the major sockeye producer in the Stikine drainage. However, spawning surveys (NNRS, 1978, Jones and Tsui, 1979, McCart, 1980) revealed considerable spawning in mainstem side-channels, sloughs and tributaries of the Stikine and Iskut including the Chutine, Craig, Inihini, Katete and Scud rivers. While populations have not been accurately enumerated, NNRS counted a total of 2623 sockeye (12 percent of total estimated Stikine escapement) in the side-channels of the Stikine and Iskut. They suggested that because of poor visibility only a portion of stocks were observed. They observed that sockeye in the Stikine mainstem between the Chutine and Scud rivers were spawning in tributary-fed sloughs or side-channels, or in areas with significant groundwater intrusion. Studies by AEL (1982a) including analysis of water chemistry, support this observation.

It is likely that at least in some years a significant percentage of sockeye spawning originates from main river spawning stocks. AEL (1982a) has shown that scale circuli patterns can be used to discriminate between lake and river rearing in over 90 percent of the fish captured in 1980. These data indicate that 69 percent of the 1980 sockeye captured were river type. AEL (1982a) recorded water depths, temperatures and velocities and gravel size for sockeye salmon spawning in the Stikine. In four instances redds were 50 to 60 cm above water at the time of observation. In several other spawning areas redds were in immediate danger of dewatering if levels declined further.

Sockeye fry emerge in the Stikine and Iskut in late April and early May. Peak fry catches in inclined plane traps in the Stikine and Iskut rivers occurred on 8 May and 16 May respectively in 1980. As might be expected of a typically lake-rearing species, river-rearing sockeye fry show a preference for slack water areas in sloughs and backwaters (IEC Beak, 1983, AEL, 1982a). However, as falling water levels in the Stikine cause many of these large low velocity backwaters to dewater, sockeye fry move into slack side-channel and slough areas nearer the mainstems.

Sockeye salmon typically rear in fresh water (usually a lake) for 1 year, and this is reflected in the results of adult scale analysis in 1979 and 1980. Except for those fish taken in the lower Stikine, approximately 95 percent of all returning adult sockeye had spent 1 year in fresh water. Most of the remainder reared for 2 years in fresh water. Of 789 sockeye taken from the lower Stikine fishery, 10.1 percent had migrated to sea in their first year of life. These fish presumably rear in the estuary for some period. Estuarine marsh channel seining (Beak, 1982) captured small numbers of sockeye fry. Of the fish identified by scale analysis as river type, 15 percent migrated to sea as fry while a sample from Tahltan River (lake type) showed no first year migrants.

Analysis of the stomach contents of fish rearing in the Stikine River show that like chinook, terrestrial insects made a major contribution to sockeye fry diet, (AEL, 1982a). However, 1983 studies indicated that aquatic organisms were dominant food of rearing sockeye (AEL, 1984). Therefore, large seasonal variability in diet can be expected and is likely related to food availability.

Coho

Adult coho migration and spawning is rather protracted compared with other salmon species. Stikine coho mature at 3 (75 percent) and 4 (25 percent) years of age after spending one season at sea (NNRS, 1979) and begin river entry in July. Peak migration through the lower Stikine usually occurs in September, and spawning peaks in November (AEL, 1982).

Coho spawning is also widely distributed within the Stikine and Iskut drainages. They do not spawn in side-channels to the same extent as sockeye, but rather utilize major tributaries including the Chutine, Craig, Inhini, Katete, Scud and Tahltan rivers (NNRS, 1979, McCart, 1980, AEL, 1982). Coho also utilize many small, often unnamed tributaries. NNRS (1979) observed between 1000 and 2000 coho spawners in each of two such creeks. Beak (1982) observed fry in many isolated beaver ponds and small tributaries on the Alaskan reach. Many of these areas had no fry access even during freshet, and could only have been seeded by adults. While many of these areas individually may only support small numbers of spawning coho, there are many hundreds of such areas along the Stikine and Iskut rivers and their accessible tributaries.

Coho fry emerge in April and May, and many rear in beaver ponds and slack water areas in the immediate vicinity of spawning areas. Others, particularly those which emerge in large tributaries or near the mainstem of the Stikine and Iskut, move downstream in search of rearing areas (AEL, 1982a).

Coho fry catches in inclined plane traps and beach seines in mainstem areas of the Stikine decline rapidly after early spring. Rearing coho are not common in mainstems and side-channels, but are found in large numbers in beaver ponds and warm slack water tributary habitats in the floodplain. Glacial tributaries do not appear to produce many coho.

In late summer as water levels drop in the floodplain, more coho are captured near the mainstem, particularly side-channels dominated by tributary flow (Beak, 1982).

Coho fry in the Stikine rear for 1, 2 or 3 years in fresh water, and despite suggestions to the contrary, (AEL, 1982a, Volume 1, page 30) are not known to use the brackish water areas of the estuary. Coho have been reported in numerous small tributaries which drain into the estuary, and this may explain earlier references.

Large numbers of coho rear in various floodplain lakes and ponds in Alaska, and while many of these fry are known to be the progeny of local spawners (Beak, 1982) the importance of these areas to fish which move downstream in the mainstem following emergence has not been assessed.

Pink

Pink salmon mature at 2 years of age and first enter the Stikine in early July. Peak catches in the Canadian fishery occur in late July to mid-August. Few pinks enter Canadian waters to spawn, and constitute only a small percentage of the total Canadian harvest (8.1 percent in 1979 and 1.6 percent in 1980) (AEL, 1982a). Alaskan net fishery catches have declined from an annual average of 40 800 in the 1960s to 9100 in the 1970s.

In the Alaskan section of the river spawning populations are concentrated in North Arm Slough area and Andrews Creek area with a mean annual escapement of 6200 and 7250 fish respectively (for the years 1971 to 1981). Both even and odd year runs of pink are common in the Stikine although in recent years odd year stocks appear to be dominant.

Pink fry emerge in April and migrate immediately to sea. In 1980, peak catches of fry in the estuary and in marine waters off the delta drop-off, occurred in early May (Beak, 1982).

Chum

Stikine River chum salmon mature at 3 (75 percent) or 4 (16 percent) (rarely at 2 or 5) years of age and enter the Stikine River in July. Peak catches in the Canadian commercial fishery follow those of pinks by about 2 weeks.

Few chum spawn upstream of the Canadian border. In 1979 and 1980 chum salmon comprised only 1.7 and 2.7 percent of the Canadian commercial catch (AEL, 1982a). In 1980, 400 chum were observed in two small unnamed tributaries of the Iskut River, one near the Inhini River, and one near Hoodoo River (AEL, 1982a), in areas that were also being used by sockeye salmon. Major spawning populations in Alaskan sections of the Stikine River occur in North Arm (Salmondog Creek), Andrews and Bluewater creeks.

Chum fry emerge in April and migrate to sea. Catches of chum fry declined from the onset of surface trawl studies off the Stikine estuary in April 1980, but small numbers were captured through May. Chum salmon were abundant in beach and marsh channel seine catches in the estuary and offshore beaches through May. The few available data suggest chum move through the estuary more slowly than do pink salmon, and rear for a brief period as they migrate to sea.

Steelhead

Little is known of the spawning or rearing patterns of Stikine steelhead. Spawning is known to occur in the Tahltan River system and possibly other major tributaries. Adults migrate into the river in fall and probably hold over winter in the mainstem near tributary confluences before moving into tributaries to spawn in spring. Extended rearing probably occurs in tributary areas.

Dolly Varden and Cutthroat Trout

Dolly Varden Char and coastal cutthroat trout are widely distributed in the lower Stikine and Iskut River drainages. Life histories of both species in the Stikine system have not been studied to date.

Adult Dolly Varden have been observed following and feeding on eulachon spawners during spring. These fish also follow adult salmon runs upstream in the fall to feed on lose eggs that drift from spawning areas. Spawning probably occurs during October and November.

Juvenile Dolly Varden have a ubiquitous distribution within the drainage.

Mature cutthroat have been observed in October and April. Presumably, cutthroat trout migrate into spawning streams on the Stikine River during fall and spawn during winter and early spring.

Juvenile cutthroat are observed throughout the lower Stikine River floodplain and in numerous valley tributaries. Areas in the Alaska floodplain of the Stikine River, such as Barnes lake, Twin Lakes and Andrew Creek support a small recreational cutthroat fishery.

Eulachon

Eulachon usually return to the Stikine at 3 years of age (75 to 91 percent) and rarely at 2 or 5 (4 to 15 percent) years of age. Eulachon begin to shoal in the Stikine estuary in March and spawning migration takes place in waves (usually two). Spawning is restricted to the lower 25 km of the river under tidal influence (Franzell & Nelson, 1981; Beak, 1983).

The factors which trigger the upstream movement of eulachon into the river have not been fully determined. In the 3 years of record (1979, 1980 and 1982) the first wave of spawning took place in the second week of April and was coincident with the beginning of spring breakup and rising flows and temperatures. However, in 1982 migration was strongly dependent on tidal flux (the difference between high and low tide) (IEC/Beak, 1983a). Although the relationship between tidal flux and eulachon migration timing was not examined in 1979 or 1980 (Franzell & Nelson, 1981), it is likely that while the spawning migration generally coincides with rising spring flows and temperatures, the precise timing of movement into the river and spawning depends greatly on large spring tides.

Although eulachon spawning is restricted to the lower section of the river under tidal influence (i.e. below

Shakes Slough), precise spawning areas have not been located. Spawning may be distributed throughout the area. Some authors working in other systems, have observed the greatest concentrations of eulachon eggs on coarse sand or small gravel substrates (see Beak, 1983 for a review), but active substrate selection has not been observed in the Stikine River.

Stikine River eulachon eggs probably hatch from mid-May to mid-June depending on spawning date and temperature. Larvae move directly to the estuary.

Starry Flounder

Very little life history data has been collected specific to starry flounder in the vicinity of the Stikine River. Other populations in British Columbia mature at 2 years of age for males and 3 years of age for females (Hart, 1973). Spawning takes place in shallow water in early spring. Eggs are buoyant and at hatch, larvae are symmetrical, and about 2 mm in length. The pelagic larvae eat copepods and their naphlii, barnacle larvae, and cladocerans. Transformation to asymmetry occurs at about 10.5 mm and the juveniles begin rearing in sandy nearshore areas of the Stikine estuary following transformation.

Beach seine studies in the summer of 1980 (Beak, 1982) indicate that both age 0+ and 1+ starry flounders rear in the Stikine estuary. These studies also indicate similar sandy beach areas outside the estuary are not used as rearing areas by starry flounders.

Shellfish

The life histories of the various shrimp, prawns, crabs and clams harvested in the Stikine area have not been documented. It is sufficient to note that none of the harvested species are dependent on reduced salinity associated with the Stikine estuary. Some populations may depend to some extent on increased productivity, or fine particulate substrate associated with the Stikine estuary.

(ii) Transmission Area Resources

A. Area 2

Due to barriers to upstream migration on the Stikine and Iskut rivers, there are no anadromous fish in this area. Most lakes and streams do, however, contain rainbow trout, Dolly Varden char, mountain whitefish and in some arctic grayling.

The many lakes in the northern half of the area (Morchuea, Kluachon, Eddontenajon, Tatogga, Kiniskan and Natadesleen) support important sport and Indian food fisheries. The creeks entering these lakes are important spawning and rearing areas, particularly the lower reaches; the upper reaches are often inaccessible and generally less productive due to steep gradients. Bog/swamp areas exist about Morchuea Lake/Creek, along Todagin Creek and south and east of Natadesleen Lake. It is not presently known if these bogs/swamps are continuous with flowing water; if they are they may be important for rearing.

Further south only Bob Quinn Lake and those lakes immediately adjacent are used to any great extent for sport fishing. Access to many of the lakes in this area is not developed and this undoubtedly contributes to their lack of use. There is no known native food fishery associated with these lakes or the Iskut and Ningunsaw rivers.

B. Area 3

The Bell-Irving River, a tributary of the Nass River is accessible to anadromous fish. All five species of Pacific salmon and steelhead trout make use of the river for migration, spawning or rearing. Resident populations of rainbow and Dolly Varden are also present. In tributary streams spawning and rearing habitat for salmon and steelhead is almost exclusively located in the lower reaches and at their confluences with the mainstem river. The Oweegee Lake and creek system is particularly important for coho, sockeye, chinook and steelhead. In the area where the transmission line would cross the tributaries to the east of the Bell-Irving River, only resident fish are present. There is no native food fishery along this system.

The Meziadin River is also a tributary of the Nass and supports a major run of salmon; of note is the sockeye run (approximate escapement 400 000 fish). Hanna and Tintina creeks to the east of Meziadin lake are extensively used for spawning and rearing and are located in an area of flat, swampy ground. Falls on both creeks prevent use by anadromous fish of their upper reaches. However, rainbow trout are present in these areas as well as downstream. There is presently no major sport or food fishery associated with Hanna or Tintina creeks.

Between the Nass River crossing and the Cranberry River the transmission line would traverse an area of generally rocky terrain containing a large number of lakes. The Nass River valley to the west is deeply incised and tributaries have steep gradients near their confluences with the mainstem which prevents use of their upper reaches by salmon and steelhead. Important spawning habitat for salmon and steelhead is located in the lower reaches of the tributaries and in the mainstem downstream of their confluence with the Nass River. The lakes and streams of the area do contain populations of rainbow and Dolly Varden. The falls on Brown Bear Creek may be made passable as part of the Salmonid Enhancement Program, thus making this drainage (including Brown Bear Lake) accessible to anadromous fish. The Nass River to the west of the transmission line route is a very important native food fishery.

In the Cranberry/Kitwanga River valley the transmission line would cross tributaries of these rivers. Both contain important spawning and rearing habitat for chinook and sockeye, and particularly coho and steelhead, but the tributaries are characterized by steep gradients. There use by anadromous fish for spawning and rearing is therefore restricted to the lowest reaches.

The Skeena River in the area of the transmission line crossing is limited to a migration route for all species of salmon and for steelhead trout. Further south the line would approach the Kitseguecla River which is a moderate value migration route for coho (2000), pink

(300) and chinook (50) salmon and steelhead. This area is also characterized by high, unstable banks where failures have already occurred. The upper reaches of both the Kitseguecla and Zymoetz rivers are accessible to salmon and steelhead and contain spawning and rearing habitat. The Aldrich/ Dennis lakes area is low lying and marshy with potential for improvements via the salmonid enhancement program. At present this area supports runs of sockeye (10 000) and coho (5000) and steelhead.

South of the Zymoetz drainage the line would cross or lie near the Pine, Telkwa and Bulkley rivers. Only tributaries of the Pine River would be crossed; no special fishery exists in these areas. The Telkwa and Bulkley rivers and their tributaries e.g. Goathorn Creek, are important migration routes and contain important sport fisheries. Only the Bulkley contains special habitat in the region of the transmission line crossing, i.e. an area where pink salmon spawn.

(c) Expected Impacts

(i) Generation and Downstream Areas

A. General Impacts

Construction

Assuming good environmental construction practices and inspection, the development should have negligible effect on fish populations located downstream. The only possible impact of significance being increased fishing pressure due to increased population.

Closure and Initial Reservoir Filling

Discharge during reservoir closure would be characterized by: 1) a short-term interruption of flow from closure to the time at which water levels in the reservoir reach the first outlet (1 to 20 hours for the Stikine and less than 1 hour for the Iskut) followed by 2) unrestricted flows until diversion tunnels are sealed.

Under most scenarios, the effects of diversion closure would be slight and of short duration. Under the worst case situation, a rapid decline in discharge with low flows would last about a day and could result in:

1. Stranding of juvenile fish.
2. Disruption of spawning activity in locations where flow is derived entirely from mainstem discharge.

Winter flows would generally be low (naturally as well as during reservoir filling) so desiccation of redds is unlikely to be important.

Once downstream flow from low level outlets is possible, a discharge of 10 percent of the normal mean annual discharge at that location will be released from November to April. Thereafter during filling, flows would be increased to 30 percent of the normal mean annual discharge. During these later filling phases, the potential for downstream fish habitat impacts will be reduced but not eliminated by the planned flow releases. Although no quantitative estimates are as yet possible the potential fish habitat impact concerns are:

1. Exposure, drying and/or freezing of eggs and alevins in redds completed at higher discharges before the 1 November onset of reservoir filling.

2. Insufficient flow or water cover to maintain water quality within redds and/or allow emergence.

3. Stranding of juvenile fish in overwintering areas.

4. Reduction of suitable rearing area in mainstem Iskut and Stikine rivers from April through September.

5. Reduction of access to floodplain and tributary rearing areas.

6. Stranding of rearing juveniles, especially during periods when fluctuating discharges are superimposed over already low flows.

7. Disruption of upstream migration of adult salmon and steelhead including possible delays in river entry, possible problems gaining access to tributary spawning areas and reduced holding areas for overwintering steelhead.

8. Reductions in the amount of suitable mainstem spawning areas.

Operation

During normal operation the annual hydrograph of the Stikine and Iskut rivers would be characterized by:

1. Higher winter discharges; four to seven times higher than normal at Telegraph Creek, and two to four times higher near the estuary.

2. Lower summer discharges; two to four times lower than normal at Telegraph Creek, and 1.1 to 1.5 times lower near the estuary.

The rising limb of the spring hydrograph would be delayed up to 2 weeks. During annual refilling of the Stikine Canyon reservoir, June, July and August flows at Telegraph Creek could be three times lower than average recorded flows (Jones, 1984).

Power demands could also result in frequent and rapid short-term increases and decreases in flow.

Increased winter discharge and decreased summer floods would probably benefit fish populations in mainstem areas. The higher flows would reduce the likelihood of freezing and desiccation of redds and improve the overwintering environment for juveniles. However, delays in the rising limb of the spring hydrograph and reductions in summer floods may delay or reduce fish access and egress from floodplain habitats that are isolated from the mainstem except at high flows.

Short-term fluctuations (i.e. over a period of hours or days) may:

1. Disrupt spawning activity.

2. Expose redds.

3. Strand spawning and rearing salmon.

4. Reduce benthic productivity, thereby reducing food supply for rearing fish.

5. Affect the efficency of the native fishery of Telegraph Creek.

These impacts would be most severe if fluctuations in discharge are:

1. Large relative to the base flow.

2. Superimposed over already low flows.

3. Rapid, particularly when levels are declining.

Or if they:

1. Occur during critical life history stage (i.e. spawning and rearing).

2. Occur during darkness when fish may be less able to detect changes or are in shallower habitats.

Once operational the changes in the hydrological regime would reduce the incidence of flooding on the rivers. Reduction in magnitude, frequency and duration of floods would effect vegetation colonization and possible succession patterns. However, reduced magnitude of floods could also:

1. reduce the souring and destruction of redds in the fall;

2. reduce the mortality of rearing juveniles during the summer;

3. possibly decrease nutrient delivery (carbon) to the estuary; and

4. reduce boat access for recreation on the floodplain of the lower Stikine River.

Sediment Transport

Reductions in sediment load would decrease water turbidity and over the long term contribute to changes in channel morphology. While the sediment trapping efficiencies of the reservoirs can be determined, the resultant changes in turbidity and suspended sediment loads are difficult to assess. In lower reaches of the Stikine River, turbidity may actually increase during spring, as flood flows from turbid tributaries such as the Scud and Chutine rivers combine with reduced flows of clear Stikine water. Turbidities in mainstem Stikine and Iskut rivers can be expected to be reduced, particularly during summer and fall.

Reduced sediment loads may:

1. Increase the population of benthic invertebrates.

2. Improve the permeability of spawning gravels in the Iskut and possibly the Stikine River.

Reduced turbidity may:

1. Slightly improve conditions for fish rearing in mainstem areas by increasing their feeding efficiency.

2. Increase predation on fish rearing in the mainstem.

Water Temperature

Water temperature in the Stikine and Iskut rivers would be warmer in winter and cooler in summer because of the averaging effects of the reservoirs (Jones, 1984). The Stikine Canyon reservoir releases would be up to 4 to 6°C warmer in winter and up to 5°C cooler in summer, while Iskut Canyon releases would be up to 2.5 to 4°C warmer in winter and up to 2°C cooler in summer. Near the estuary, temperatures would deviate from unregulated temperatures in the same pattern, but by less than 0.5°C (Jones, 1984) because of tributary influences. In the estuary, mixing with marine waters would further reduce the effects of any temperature change.

The major potential impacts of temperature changes on fisheries resources are:

1. Increased development rate of salmon eggs exposed to warmer mainstem temperatures during winter.

2. Reduced productivity and reduction of growth of mainstem rearing salmon due to lower summer temperatures.

3. Reduced incidence of anchor ice, thus improving overwintering of eggs, larvae and juveniles.

The extent to which development rates of salmon eggs incubating in the mainstem are accelerated depends on the relative contribution of mainstem flow and groundwater in incubation, and the physiological response of Stikine salmon eggs to increased temperature. Both of these issues are currently under study. However, any salmonids which do spawn in mainstem areas of the Stikine and Iskut rivers without groundwater influence are at risk. Even a relatively small temperature increase (i.e. less than 1°C) can accelerate development and significantly advance emergence. Advancing emergence by weeks or months would potentially cause significant mortality because little food could be available for these premature emergents. Although, the effect of elevated temperature on food availability would have to be known to confirm this. In addition, it should be noted that where spawning has been observed in mainstem areas, it has occurred in areas associated with groundwater upwelling or tributary influence (NNRS, 1979, AEL, 1982a).

Decreased mainstem summer temperatures would tend to decrease the growth rate of aquatic invertebrates and fish. Growth rate at any given temperature would depend on the optimum for the species in question, and temperature fluctuations as well as mean daily temperatures, and food intake.

Results of a hypothetical growth modelling study (AEL, 1984) suggest that growth rates for rearing chinook salmon would not be greatly affected, in part because warmer temperature extends the fall growing season. Effects of any reduction in food availability were not considered in this analysis.

Finally, because the Stikine Canyon and Iskut Canyon reservoirs will be stratified during summer, rapid changes in water temperature downstream may result from withdrawal of hypolimnial water by low level outlets (e.g.: during spilling) which could have quite a different temperature than that of the epilimnial water.

Dissolved Gas Supersaturation

Gas supersaturation is usually associated with reservoir spilling when entrained gases are carried to depth in the plunge pool. Spilling would likely be a fairly common occurrence from July through October at both the Iskut and Stikine Canyon reservoirs, particularly during wet years. The amount of supersaturation depends on the spillway type. The spillways proposed for the Stikine-Iskut development (flip bucket) and jet flow gates are reported to cause the least amount of gas supersaturation.

Saturated gases also rapidly equilibrate in turbulent river waters, and would be diluted by tributary inflows. While major gas supersaturation problems are not anticipated in the Stikine and Iskut rivers, further study is required to accurately predict levels in release waters. Adult salmon are particularly vulnerable. Sockeye and chinook migrating to the Tahltan and Tuya rivers would be of particular concern, as would steelhead overwintering below the Tahltan River confluence.

River Morphology

Morphological changes in the Stikine and Iskut rivers resulting from development are difficult to predict

(Jones, 1984); therefore, the same holds for the impacts of these changes on fisheries resources.

It is reasonable to assume that where channel morphology is greatly simplified spawning and rearing habitat would be lost. This loss may reduce areas available for egg deposition or egg and fry survival. The greatest morphological changes would be expected in the Iskut River above the Hoodoo River and in the Stikine River above the Chutine River. Impacts on spawning sockeye and rearing chinook are the greatest concern. However, a quantitative relationship between channel simplification and fish habitat availability has not been established.

Rearing salmon are not abundant in side-channel and mainstem areas of the Iskut (AEL, 1982), although those present may be affected by habitat reduction. In the Stikine, rearing chinook are likely to be affected if rearing habitat is lost.

Estuary

Potential impacts of Stikine-Iskut hydroelectric development on the Stikine estuary are addressed in detail in Beak (1982). The major potential impacts identified by these studies include:

1. Reduction in the growth rate and possibly erosion of parts of the Stikine sand flats.

2. Reductions in turbidity and subsequent effects on plankton production, possibly reducing the food supply for fish and shellfish and increased predation rates.

3. Reductions in the delivery of organic carbon to the estuary with possible reductions in benthic productivity.

4. Changes in patterns of salinity penetration to the possible detriment of certain species adapted to the current regime.

Changes in estuarine morphology are expected to be minor, with present growth continuing at a reduced rate. Beak (1982) concluded that significant widespread erosion is unlikely.

Should significant erosion occur, the consequences for fisheries resources are difficult to assess. Even with project development the sediment load in the Stikine River would be large enough to maintain a large and active delta. If, at worse, losses in sand flat areas are equal to the decrease in sediment supply, there may still be little or no impacts on fisheries resources, with the possible exception of starry flounder.

Changes in river and therefore estuarine turbidity, have not been quantified or have the biological consequences cannot be quantified. Results of numerical plankton productivity models (Beak, 1982) suggest that major changes would be unlikely. Similarly, the importance of organic carbon contributed by the Stikine River to productivity of areas off the delta break used by crab and shrimp, has not been established. Further, there is no estimate of how development would affect the quantity of organic carbon carried by the Stikine River or its spatial and temporal distribution.

In summary, despite considerable study, we are not able to quantify the possible impacts of development on estuarine fisheries resources. However, physical changes are expected to be minor and the use of the estuary by economically important fisheries resources appears limited.

Reservoirs

The river upstream of the proposed dams currently produce few fish, have a steep gradients and are inaccessible to anadromous fish.

AEL (1982a) concluded that each of the reservoirs would be likely to undergo a short-term increase in fish production following inundation. Productivity would be reduced in the long term by the adverse effects of drawdown and consequent bottom exposure, steep topography (small littoral area), and, for all but the Stikine Canyon reservoir, an absence of tributaries suitable for spawning and rearing fish. Flooding of existing resident fish spawning areas in the tributaries to the Stikine River above Highway 37 may be mitigated by creation of new spawning areas at higher elevations.

With enhancement, the Stikine Canyon and Iskut Canyon reservoirs may produce sportfishing opportunities. It should be noted, however, that natural lakes and streams with excellent sportfishing potential are common in the immediate areas.

In summary, fisheries losses from reservoir flooding would be small, as would be any potential benefits.

C. Species - Specific Impacts

Salmon

Chinook

Chinook salmon are potentially the most sensitive salmon species to the development. Chinook fry rear for a full year in mainstem and side-channel areas, and rearing fry are distributed well upstream, to the Tahltan River and beyond. Rearing chinook fry would therefore be particularly vulnerable to downstream effects including:

1. Short-term fluctuations in flow causing stranding.
2. Reductions in rearing habitat available resulting from lower summer flows and simplification of channel morphology.
3. Reduced growth because of lower summer temperatures and reduced benthic invertebrate production.

Chinook are the only species of salmon which may spawn in appreciable numbers in the central portions of the Stikine mainstem. Although no mainstem spawning has been documented, the survival of eggs deposited in mainstem areas could be severely affected by increased temperatures. Some buffering effect could be created if the spawning takes place in areas influenced by groundwater. Finally, any spawners utilizing mainstem areas near the dam sites or migrating to tributary spawning areas in the Tahltan or Tuya rivers could be adversely affected by dissolved gas supersaturation, should it occur.

Sockeye

A significant proportion of Stikine River sockeye spawn along the margins of the mainstem and in side-channel areas. Although available evidence suggests that these fish are spawning in areas of significant groundwater or tributary influence, spawning could still be disrupted by lower water levels and rapid water level fluctuations. Further, eggs in redds along the mainstem could be affected by warmer winter water temperatures. Spawners moving into the major spawning areas in the Tahltan system may be affected by low water entrance conditions at the mouth of the Tahltan and/or by gas supersaturation.

River type sockeye rear in slack water areas along the margins of sloughs and side-channels, and in mainstem back waters. Some reduction in sockeye rearing area can be expected as a result of lower summer water levels.

Coho

Coho salmon neither spawn nor rear in appreciable numbers in mainstem or side-channel habitats. Coho spawning could be affected if entrance conditions to tributary spawning areas become difficult. However, because coho spawn relatively late in the year in small numbers and in a large variety of tributary areas, and are tenacious migrators, impacts on spawning success would be minor, at worst.

Coho fry displaced from upstream areas move down the mainstems in early spring and move into floodplain tributary habitat to rear. Lower water levels in spring and delays in spring floods could prevent or delay the movement of these fry into suitable rearing areas. Unfortunately, the contribution of these fry to total Stikine production is not known, however, some mortality of these fry is possible, particularly in very dry years.

Finally, the abundance of coho rearing areas may be affected, particularly in lower reaches of tributaries where water levels are dependent on hydraulic damming by the Stikine. In the longer term, reduced Stikine water levels and a reduction in the intensity and duration of flood peaks could result in a general reduction of water levels in the floodplain. While most if not all coho rearing areas depend primarily on tributary inflows, some reduction in habitat availability could be possible.

Chum and Pink

Chum and pink salmon in the Stikine River spawn primarily in tributaries of the lower Stikine and Iskut rivers and do not rear for any appreciable period in fresh water. Only significant changes in estuarine productivity, which are not predicted, would have the potential to reduce pink and chum fry survival.

Eulachon

Eulachon spawning and egg development could be potentially affected by changes in flow, temperature and substrate.

Eulachon spawning in March or early April would encounter somewhat higher flows, while those in late April and May would, on average, encounter normal or slightly lower flows. In general, the flows following project completion would be well within the unregulated natural range and are unlikely to significantly affect either the timing or distribution of eulachon spawning. Water temperatures in the Stikine during eulachon egg incubation could be as much as 1°C higher than pre-regulation values. This could advance eulachon hatch by as much as a week. It is also possible that spawning would be slightly advanced by increased water temperatures. The more rapid development and early spawning may disperse eulachon into offshore waters earlier than usual. Depending on the timing of plankton production offshore, the growth and survival of larval eulachon could be reduced.

Starry Flounder

Since only minor changes in shallow sandflat areas of the Stikine estuary are anticipated, impacts on starry flounder populations are expected to be slight.

Shellfish

The distribution of shrimp and crabs in the area of the Stikine River suggest that they are at best tolerant of reduced salinities, and not dependent in any way on flows of fresh water from the Stikine.

It is possible that shrimp and crabs utilize particulate organic matter contributed by the Stikine River or are to some extent dependent on increased productivity of offshore areas. If, at worst, changes in benthic productivity in the immediate vicinity of the Stikine River were proportional to river flow, impacts on shrimp and crab populations would be minor and restricted to a small area off the delta break.

(ii) Transmission Areas

Most impacts to fisheries due to transmission line construction could be avoided with the use of appropriate construction practice. Approriate design and construction of access roads and stream crossings and a requirement for hand clearing adjacent to creeks are normal practice to minimize or eliminate detrimental impacts on fish and their habitat.

The assessment of the impacts of transmission line construction and operation assumes that a program of environmental protection would be designed, specified, implemented and inspected. Given this, impacts are provided in terms of potential changes to habitat in areas of particularly unstable terrain and changes in sport fishing pressure due to changes in access and population. The limited data preclude a quantitative prediction, hence all impacts are assessed in qualitative terms. Effects on food fisheries are also briefly discussed.

A. Area 2

The potential for terrain-related impairment to spawning and rearing habitat exists in the area near Morchuea Lake. Construction in this area would be difficult due to the low lying, wet land. Although any disturbance-related to construction would be of short duration it would probably take a substantial period of time (5 to 10 years) for repairs to habitat to occur. Careful construction practice and controls would be required in this area to prevent disturbance to this important sport and food fishery. Winter construction maybe one viable means of minimizing the disturbance. For the balance of Area 2 adverse effects from construction should be avoidable using standard practice.

Increased fishing pressure due to the increased population would be expected. This would affect all lakes and streams in the north half of the area but particularly those nearest to the proposed new townsites (at the dams) Morchuea, Kluachon and Eddontenajon lakes. Increased angling pressure would result in less success for present users. Native food fishing would be adversely effected.

Lakes and streams near the Bob Quinn townsite would also suffer from increased angling pressure due to the increased population. Access developed for the transmission line would permit fishing in previously inaccessible lakes and streams nearby. Initial success would be high but once the older, larger fish have been caught the success rate would drop as the resource is depleted. In the long-term and once the large construction phase workforce is reduced some recovery of fish stocks may occur. Due to the expected increase in tourism in the area, increased angling pressure on these lakes may occur regardless of whether or not the project proceeds. Any effect of the project workforce would add to this increased angling pressure. Careful management of the resources would be required.

B. Area 3

For the majority of the transmission route, adverse impacts on the fisheries resource, due to physical disturbance, may be avoided through the use of proper construction practice and timing of construction. Changes to the conditions of fish habitat should not materially affect either resident or anadromous fish. Three areas merit special attention due to their particular fisheries values and the local terrain. These are:

1. Hanna and Tintina creeks;
2. the Kitseguecla River; and
3. the Aldrich and Dennis lakes area and upper Zymoetz River.

Hanna and Tintina creeks are part of the Meziadin River system and are prime spawning and rearing habitat for large numbers of salmon, especially sockeye, and steelhead. The area is relatively flat with many swamps. The creeks themselves are small relative to their importance as fish habitat. Construction through the area has the potential to cause serious damage to these highly productive streams. Caution is required during access development and construction.

The Kitseguecla River supports moderate runs of coho, pink and chinook and steelhead. The portion of the river used for migration passes through steep and unstable terrain which shows evidence of recent mass failures. The proposed route would lie close to the river in this area of unstable terrain and care would be required to avoid construction related slope failure which could impede or prevent upstream migration of fish. Provided no failure occurs, there would not be any adverse effect on fish; otherwise the run could be lost.

The wetland/swamps in the Aldrich/Dennis lakes area of the upper Zymoetz River drainage are also vulnerable to disturbance due to unstable terrain. Care would be required during clearing and construction in this area of important spawning and rearing habitat.

The development of new access would open to anglers a large number of previously unfished lakes and streams. The area between the Nass and Cranberry rivers would probably be affected most due to the abundant resident fish resource and due to it being relatively close to population centres. Initially considerable angling success would be enjoyed in the newly opened areas. However, this success would decrease over the medium term as the mature stocks are depleted. Over the long term self-regulation of the resource would probably be established but at a lower population than at present.

New access development north of the Nass crossing would also increase sport fishing in previously unfished streams. However, this would be unlikely to be a major pressure due to the low population and not particularly abundant resource. Along the southern portion of the route south of Dennis/Aldrich lakes access is already well developed and sport fishing pressures are unlikely to change.

Considering the location of the transmission line route in relation to mainstem rivers, adverse effects of increased angling presure on anadromous fish are unlikely.

(d) Conclusions

(i) Downstream

Impacts to fish habitats which could result from hydroelectric development of the Stikine and Iskut rivers cannot yet be quantified. Unfortunately, even an accurate quantitative estimate of fish habitat loss is unlikely to allow a quantitative estimate of losses to major fish populations with a useful level of accuracy.

Expert opinion, as expressed in the various supporting documents, suggests that impacts on fisheries resources could result from:

1. loss of mainstem rearing habitats; affecting primarily chinook salmon fry but also sockeye fry and possibly coho fry;

2. reductions in sockeye spawning habitat;

3. warmer winter water temperatures which may affect development rates of chinook and sockeye eggs and fry, and reduce summer temperatures affecting rearing chinook, sockeye and possibly coho;

4. short-term fluctuations in discharge which may disrupt mainstem spawning; primarily affecting sockeye, but also affecting chum and possibly chinook salmon; and

5. dissolved gas supersaturation affecting migrating adult chinook and sockeye and possibly coho, particularly those migrating to the Tahltan and Tuya rivers, and rearing

chinook and sockeye particularly those fry rearing in the Stikine and Iskut reaches near the proposed dams.

These downstream impacts could be either mitigated by altering project operating regimes and modifying design criteria, or could be compensated for through development of alternative habitats in the Tuya River or other areas.

Estuarine impacts would be less likely to occur, more difficult to accurately predict, and less easily mitigated. Possible estuarine fisheries impacts include:

1. reduced estuarine productivity or changes in the distribution of zones of maximum estuarine productivity affecting out migrant salmonids, especially chum fry and also pink fry as well as chinook, coho and sockeye smolts and rearing starry flounder and eulachon;

2. losses of estuarine sand flat habitat utilized by starry flounders; and

3. changes in salinity profiles altering migration patterns for out migrant salmon fry and smolt and reducing available habitat for starry flounders.

(ii) Reservoir Area

Fisheries studies suggest that the effects of reservoir flooding on resident non-anadromous fish in the Stikine and Iskut rivers and tributaries would be minor. In addition, short-term increases in fish productivity may occur because of the presence of new lake environments. Additional studies will be required to assess the effects of flooding on the amount of spawning habitat available for these resident fish.

(iii) Transmission Area

Impacts of transmission line construction and access on fisheries resources are expected to be minor.

5.2.8 Wildlife

(a) Summary of Studies Conducted

(i) Downstream (Area 1)

A limited number of wildlife studies have been undertaken in the area downstream of the proposed dam sites on the Stikine and Iskut rivers (Area 1). A background survey of the knowledge available on the lower Stikine River and estuary, Alaska, was completed in 1979 (Bengeyfield, 1979) and a preliminary analysis of potential impacts of hydroelectric development on the biological resources of the estuary was prepared in 1981 (Beak Consultants, 1981). Field studies on moose (Doerr, 1983; Craighead et al., 1984) and waterfowl (Jackson, 1983; Heglund and Rosenberg, 1984) were recently completed.

(ii) Generation Area (Area 2)

Wildlife work in or around the proposed Stikine and Iskut reservoirs (Area 2) started in 1977 with a brief overview (Goulet, 1978). Detailed field studies on moose habitat use (Gorman, 1982), mountain goat (Marr-Terr Enviro Research, 1981), caribou (Wyborn, 1981; Hatler, 1981, 1983), furbearers (Penner and Jalkotzy, 1982), ungulate winter range (Blood and Anweiler, 1982a) and wildlife habitat mapping (Talisman, 1984b) were completed between 1979 and 1982. Additional studies on beaver, small mammals, birds and wildlife use were done (Blood and Anweiler, 1982a). Possible impacts of the project on bears (Blood, 1982b) and on wildlife in general (Blood, 1981; Blood and Chutter, 1981; Anweiler and Blood 1982; Blood and Anweiler 1982b) were summarized. Some biophysical ungulate capability mapping (Blower, 1982; Fuhr and Demarchi, 1982; Stewart, 1982) is available for the area. A preliminary study of wildlife hunting in the Stikine area was completed in 1984 (DPA Group, Inc. 1984).

(iii) Transmission Line Corridor (Areas 2 and 3)

In contrast to the detailed information obtained in the generation area, broader scale work has been done for the transmission portion (Areas 2, 3) of the project. A 1980 overview study (International Environmental Consultants, 1982; Hayward, 1982) compared wildlife impacts among different corridor options. Based on this study as well as other environmental and technical considerations, a corridor was selected for detailed studies and impact assessment. The detailed study of this corridor initiated in the winter of 1983, included two ungulate winter aerial surveys (Erickson et al., 1983a,b), a partial review of wildlife resource use and a summary of potential impacts and mitigation recommendations (Erickson, 1983). The latter report provides most of the wildlife data presented for the transmission corridor. Finally, a specific route within the selected corridor (Fig. 5-6) was flown in September 1983 by B.C. Hydro biologists (Goulet, 1984). Wildlife impacts provided here will be assessed in relation to that route.

The wildlife data available for most of the study area, with the exception of the generation portion (Area 2), are limited as detailed studies were not all completed. Many of the wildlife studies were concerned with critical winter range for ungulates and as a rule, population levels and distribution were expressed in terms of the numbers observed during one or a few winters only. Only low to moderate snow pack conditions were encountered during these surveys, so that critical ungulate winter ranges may not have been clearly defined.

(b) Wildlife Resource Summary

(i) Wildlife Habitats and Populations: Area 1

Wildlife habitat in the estuary of the Stikine River consists of open tidal marshes. On the mainstems of the Stikine and Iskut rivers downstream of the damsites, wildlife habitats consist primarily of side channels, and alluvial areas covered with riparian shrubs and/or cottonwood/coniferous forests.

No wildlife studies have been completed on the mainstems of the Stikine and Iskut rivers between the proposed dam sites and the American border. A 1979 background study by Bengeyfield (1979) concluded that in this area, only a partial documentation of fauna and flora species composition existed. More information was obtained on the mainstem of the Stikine River below the international border and on the estuary. U.S. Fish and Wildlife biologists have ascertained that the Stikine floodplain offers good wintering habitat for moose and the estuary is used by Sitka black-tailed deer, migrating waterfowl and shorebirds. Hunting is an important recreational activity in these areas. Side river channels support populations of beaver and muskrats. Bald eagles, harbour seals, river otters, black bears and grizzly bears feed on the runs of spawning salmon and eulachon. However, critical habitats and population estimates had not been documented.

Two studies of radio-collared moose done between April 1979 and 1983 along the lower 50-km portion of the Stikine River and adjoining drainages indicated that the Stikine floodplain is a preferred winter range for moose (Doerr, 1983) and that as many as 300 animals may winter there (Craighead et al., 1984). Floodplain habitats such as riparian shrubs, spruce forest on terraces, black cottonwood forest or riparian sedge muskegs are preferred habitats (Doerr, 1983), with willow and red-osier dogwood being the major species browsed by moose (Craighead et al., 1984).

Waterbird and vegetation investigations were conducted in 1982 and 1983 in the Stikine estuary and the U.S. portion of the Stikine River (Heglund and Rosenburg, 1984). Up to 486 bald eagles were observed feeding on eulachon in the spring of 1982, while 70 nests were later counted along the river. As many as 127 000 and 384 000 birds stopped in the estuary during the fall 1982 and spring 1983 migrations respectively. Snow geese, ducks, sandhill cranes, and shorebirds were the most important groups to use the estuary. Common feeding areas were on mudflats, sandbars or lyngbye sedge marshes adjacent to the river. No concerns for rare or endangered species were identified.

(ii) Wildlife Habitats and Populations: Area 2

Blood and Anweiler (1982b) summarized and consolidated the results of all wildlife studies carried out for B.C. Hydro by several investigators. The summary given below for the Stikine and Iskut reservoir areas is taken almost verbatim from their report. Data from Erickson (1983) and Goulet (1984) are used for a description of the wildlife resources found along the proposed transmission route.

A. Stikine Area

Over 600 km^2 of wildlife habitat was mapped in the Stikine study area (1730 km^2). Coniferous forests are the predominant vegetation cover both on uplands and terraces. Burned forestland is extensive, consisting primarily of a 1958 burn north of the Stikine Canyon, and a 1969 burn to the south. Deciduous or mixed forests containing aspen are primarily on south-facing slopes; those containing cottonwood are restricted to alluvial sites. Wetlands and shrublands are mostly on the Klastline and Tanzilla plateaus and subalpine areas.

Moose are widespread and relatively abundant in the Stikine project area. Winter ranges are mostly below the 1067 m elevation, and aspen-dominated southerly exposed slopes, burns and riparian edges are preferred. Population densities in winter varied from about 0.1 to 1.4 moose per square kilometre, and averaged 0.4 to 0.54. The study area was estimated to contain about 480 moose in late winter.

Three caribou herds occur in or adjacent to the study area, the Hotailuh, Edziza and Caribou Mountain (Spatsizi) herd. These are believed to consist of under 50, 70 and 300 to 400 animals, respectively. Seasonal distribution and abundance are incompletely known. The Hotailuh herd is believed to be a remnant of larger herds in the Klastline-Tanzilla area, and to migrate across the Stikine at the east edge of the canyon. The Edziza herd rarely leaves Mt. Edziza Park. Many individuals of the Caribou Mountain herd migrate north across the Stikine in early winter and return in spring. Crossing places are primarily east of the McBride River.

The Stikine Canyon mountain goat herd consists of about 315 animals, distributed from the mouth of the Klastline River to just west of the Highway 37 crossing. About equal numbers occur on each side of the canyon. Home ranges are small, and movements mostly parallel the canyon. Few goats are thought to cross the canyon.

A few Stone's sheep occur on the north side of the Stikine between Beggerlay Creek and McBride River, and occasionally descend to the river edge at that location.

Mule deer are thinly dispersed throughout most of the study area, preferring south-facing aspen-scrub slopes and alluvial sites. Numbers are not known.

Grizzly bears are of widespread distribution in the Stikine region, but utilize primarily alpine-subalpine habitats and are therefore not abundant within the Stikine wildlife study area, which consists primarily of forested valley habitats. Black bears occur throughout the forested portion of the study area, and may also use subalpine shrub habitats. Population densities of grizzly bears were estimated one per 25 to 50 km^2 of land; those of black bears about one per 2.5 to 5 km^2.

An examination of the abundance indices of furbearers in the Stikine study area shows the Stikine study area supports a high diversity of fur-bearing mammals. Fourteen species were recorded during field studies. The area also supports relatively abundant populations of most species in relation to abundance indices reported for other boreal forest areas. Most notable are the high abundance indices for red squirrel, snowshoe hare, wolf and fisher. Indices for most other species fall within the median to upper range of indices reported from other studies in the boreal forest.

River valleys in the study area provide poor habitat for waterfowl. Up to ten pairs of Canada geese and 50 of ducks may nest in valley bottom habitats within the proposed reservoirs. No significant concentrations of migrant waterfowl occur. Blue, spruce and ruffed grouse and willow ptarmigan occur in the study area. Spring densities of 7 to 20 spruce grouse per square kilometre can be expected in upland conifer woods, and up to 50 ruffed grouse per square kilometre in deciduous alluvial habitats during cyclic peaks. At least one active and two inactive golden eagle nest sites occur along the Stikine Canyon. No nest sites of bald eagles, ospreys, peregrines or gyrfalcons were found along river valleys, in the study area. Twenty-five species of songbirds were recorded on valley bottom transects, and densities are expected to range from 200 to 500 pairs per square kilometre. At least 137 bird species have been recorded in the area (Goulet, 1978).

B. Iskut Area

About 250 km^2 of wildlife habitat was mapped in the Iskut study area (675 km^2). Coniferous forests dominated by western hemlock and Sitka spruce are the predominant cover on upland sites, and cottonwood-dominated forests on the floodplains.

Moose occur in low numbers throughout the non-alpine portion of the study area in summer. Limited winter range occurs around the Forrest Kerr-Iskut confluence. This includes burn, alluvial and pine-birch-hemlock habitats. The summer population is estimated at 50 to 75 moose, the winter population about 10 to 20. Deep snow cover and predominantly coniferous forest cover limit moose abundance in this area.

Mountain goats are widespread and common in alpine-subalpine habitats but a complete inventory has not been done. Caribou, Stone's sheep and deer do not occur.

Grizzly bears are of widespread distribution in the Iskut area, most commonly occurring in alpine-subalpine, avalanche slope, and active alluvial habitats. They are probably more abundant in the More Creek-upper Forrest Kerr Creek area than in the Iskut River valley.

Black bears occur throughout the forested portion of the study area, and may also use slide paths which occur through the forest, and subalpine habitats. The key alpine-subalpine-alluvial habitats combined might support one grizzly per 20 km^2; the total study area about one per 30 km^2, or about 30 grizzlies. The forested half of the Iskut study area was estimated to support about one black bear per 2 to 4 km^2, giving a total of 110 to 225 bears.

The number of species of furbearers found in the Iskut study area exceeds that reported for most studies in boreal forest regions. Thirteen of the 14 species found in the Stikine study area occur here; only the red fox appears to be absent. Species recorded in the study area that are less frequently recorded in other regions include the fisher, otter and wolverine.

The valleys of the study area contain very little habitat suitable for waterfowl, and few waterfowl frequent the study area at any time. Breeding waterfowl are limited to scattered pairs of Canada geese and the occasional pair of mergansers and goldeneyes. Concentrations of waterfowl are not known nor are staging areas expected in the study area. Three species of grouse (blue, ruffed and spruce) and three species of ptarmigan (willow, rock and white-tailed) occur in the study area, but only the ruffed and spruce grouse and willow ptarmigan have been observed in the study area. Blue grouse may be present in small numbers, while rock and white-tailed ptarmigan may occur in the adjacent alpine areas. Suitable breeding habitat for ospreys, eagles and large falcons is almost non-existent in the study area. No evidence of past or present nesting by any of these birds was obtained. The study area supports large numbers of both individuals and species of songbirds. Densities of 200 to 500 pairs per square kilometre are expected, with highest numbers in alluvial/riparian habitats.

C. Transmission Line

In Area 2, dense coniferous or mixed forests dominate along the proposed transmission route. Wildlife habitats for ungulates consist primarily of shrubby thickets growing in bogs, burns or along creek drainages; a few mixwoods are also used. Slow meandering creeks are occupied by beavers. Alluvial and riparian habitats along the Iskut River are not traversed by the proposed route.

In Area 2, moose is the most widely distributed wildlife species along the transmission route, with winter concentrations found along the Stikine River, around Morchuea Lake, Tsatia, Eastman and Burrage creeks, and along the floodplain of the Iskut River (Fig. 5-6). Stone sheep occur above 1200 m ASL in the mountain ranges near Kinaskan Lake. Small numbers of mountain goats occupy the upper slopes (above 300 m ASL, mostly south-facing) of the Iskut Canyon. The transmission route traverses wetlands occupied by beaver in the Morchuea/Tsaybahe and Tsatia creeks areas and generally, low numbers of beavers are found along creek drainages and lakes. The subalpine slopes south of the Stikine River are used by moose, a few wintering caribou and bears, including grizzlies. Grizzly bears in low numbers range throughout the Iskut Valley.

In addition to areas where generation and transmission activities overlap, the following wildlife areas are of special concern because they are traversed by the proposed transmission route:

Stikine Collector to Bob Quinn Collector

km 8 to 10 and
km 16 to 19 - good quality moose winter range is found. Beaver populations also occur at km 16 to 19 (No. 1 on Fig. 5-6). A small number of caribou may cross the Stikine River nearby.

km 61 to 65 - good quality moose winter range and beaver population in Tsatia Creek area (No. 2).

Other areas of concern which are not traversed by the transmission route but are close enough to be affected by possible route relocation are as follows:

Tanzilla Site to Stikine Collector

The Stikine River canyon and sub-alpine areas are used by wildlife, including moose, goats, black and grizzly bears (No. 3).

Stikine Collector to Bob Quinn Collector

km 57 - Stone sheep range is roughly 0.5 km away from the transmission route (No. 4).

Iskut River - the floodplain offers good to high value moose winter range (No. 5).

Iskut Canyon to Bob Quinn Collector

km 0 to 20 - goat range on both sides of Iskut Canyon (mostly on north shore) (No. 6).

km 3 to 35 - good value moose winter range along Iskut River (No. 7).

(iii) Wildlife Habitats and Populations: Area 3

From the Bob Quinn Collector to the Nass River, the proposed transmission route traverses mostly dense coniferous forests. A few shrubby patches on avalanche slopes or around bogs or creeks, a few sedge meadows, and salmon-spawning rivers constitute the more productive wildlife habitats for moose, beaver and bears. South of the Nass River, logging clearcuts offer additional shrubby openings in the dense coniferous cover. South of the Skeena River, clearcuts and farmland are interspersed with the mostly mixed or deciduous forests. Alluvial habitats are found in nearby areas where the transmission route skirts rivers such as the Bell-Irving, Nass or Cranberry.

Moose are distributed throughout the transmission area and this species was the most visible during the 1983 winter surveys (Erickson et al., 1983a,b). Preferred habitats were river floodplains, clearcuts, and open shrubby areas with aspen, willow or cottonwood. Small numbers of mountain goats occur on precipitous rock outcrops 1 to 4 km away from the selected route near the Ningunsaw, Zymoetz and Kitseguecla rivers and on Snowbank Creek (Fig. 5-6). Mule deer presence is scattered and restricted to a few locations in the Cranberry and Skeena valleys. Caribou are found in the Telkwa mountains, but the few individuals observed there in February and March 1983 were found in alpine areas, removed from the proposed transmission corridor (Erickson et al., 1983a,b). Grizzly and black bears range throughout Area 3, with grizzly bear concentrations in salmon spawning rivers such as the Bell-Irving, Meziadin, Nass and Cranberry rivers. Grizzlies may also be found in the Swan/Brown Bear lakes area (International Environmental Consultants, 1982). Beaver is the most common aquatic furbearer in the area, with highest densities found along the Beaverpond and Snowbank creeks. Significant waterfowl use seems to be restricted to a few lakes, such as Meziadin Lake, during the spring and fall migrations (International Environmental Consultants, 1982).

Specific areas of concern for wildlife along the proposed route (between the Bob Quinn collector km 0 to Telkwa Substation km 373) are as follows:

km 19 to 43 - wetlands with high beaver populations along Beaverpond and Snowbank creeks. Avalanche slopes and salmon spawning creeks are also excellent grizzly bear habitat (No. 8).

km 120 to 135 - Hanna and Tintina creeks in the Meziadin River area offer high value winter range for moose and are frequented by many grizzly bears during salmon spawning. Nearby Meziadin Lake and River are used by aquatic birds and migrating waterfowl (No. 9).

km 165 to 195 - new access would be provided to service the proposed route in the Swan/Brown Bear lakes area where spawning fish attract grizzly bears (No. 10).

Many other areas are valuable to wildlife, for example the Bell-Irving River floodplain supports high densities of wintering moose and attracts grizzly bears at spawning time (No. 11), but are avoided by the proposed route. This is also the case for the high value goat winter range located east of the Ningunsaw River (roughly 1 km east of proposed route) (No. 12).

(iv) Wildlife Resource Use

No resource use data were compiled for Area 1. In the Stikine and Iskut Area 2, an overview of resident sport and subsistence hunting, guide/outfitting and non-consumptive wildlife use was done (Blood and Anweiler, 1982a). However, no quantification of wildlife use was given. Neither did a recreation study by DPA Consulting (1982, 1984) provide definite numbers on wildlife harvest for the Stikine/Iskut areas. More detailed data are required to permit impact assessment. Only an approximation of wildlife harvest is given here for the total study area in British Columbia, based strictly on Harvest Sample data (B.C. Fish and Wildlife, n.d.). Results from a furbearer study (Penner and Jalkotzy, 1982) are also given for the Stikine/Iskut Area 2.

Six guiding territories border on the Stikine and Iskut rivers, with yearly numbers of hunters varying widely (Blood and Anweiler, 1982a). The number of animals harvested by guided hunters is not available, but it is known that mainly alpine species such as sheep, goat or caribou are taken. Resident sport hunting in the area is limited by the lack of access and overall, the level of wildlife utilization on the Stikine and Iskut rivers is low. Subsistence hunters, mostly native people, originate from Dease Lake and the Iskut and Telegraph Creek villages; they take mainly moose. Non-consumptive use of wildlife is still restricted and is usually associated with scenic travel. However, the potential of the Stikine area is considered to be excellent for the development of wildlife viewing trips. Overharvesting due to poaching may be a serious problem in parts of the area.

Seven wildlife species of economic importance are found in the wildlife management Region 6, which includes all of the

Stikine/Iskut project area (Table 5-10; B.C. Ministry of Environment, 1977). Region 6 (MU 6-1 to 6-29) represents 28 percent of the total area of the province. However, it contains up to 52 percent of the mountain goat, 41 percent of the grizzly bear, and 40 percent of the thinhorn sheep and caribou in the province. Moose, deer and black bears are common.

Resident hunter harvest data for those wildlife management units traversed by the project (MU 6-9, 6-15 to 17, 6-19 to 22; 10 percent of the provincial area) show that only mountain goats (19.6 percent) and caribou (18.5 percent) are taken in numbers greater than that expected based on area. Data from guided hunting would also be required, however, to obtain an accurate estimate of total species harvest. Alpine and sub-alpine species such as caribou, sheep, goat and grizzly are preferred by guided hunters, and it is expected that the thinhorn sheep and grizzly bear harvests should also be significant, regionally and provincially.

Fourteen furbearer species are trapped in the Stikine/Iskut areas (Penner and Jalkotzy, 1982). Forty-four traplines are registered, but only 25 may be active. Harvest data for 20 traplines show that between 1965 and 1981, marten (41 percent), lynx (27 percent), beaver, fisher, wolverine and wolf (23 percent) accounted for most of the income generated. Average income per trapline each year was roughly $1500 and varied from $100 to $6600. Data on native trapping were not available.

(c) Expected Wildlife Impacts

(i) Downstream (Area 1)

Previous attempts at predicting impacts on the wildlife of the lower Stikine River and estuary were made by Beak Consultants (1981) and the U.S. Fish and Wildlife Service (Jackson, 1983). However, due to the paucity of hydrological, vegetation and wildlife data, impacts were only surmized in these reports. A detailed hydrological report (Jones, 1984) is now available, which should allow more specific vegetation and wildlife impact assessment in this area.

Early successional vegetation along the mainstems of the Stikine and Iskut rivers may be replaced by more mature vegetation as a result of regulation. Reduced summer flows will diminish the ability of the rivers to carry sediments and aggrading deltas may form at the confluence of tributaries with the Stikine and Iskut rivers. A predicted reduction of flood magnitude, frequency and duration, the absence of ice scouring below dams (possibly as far down as the confluence of the Stikine and Iskut rivers), and a reduction of the sediment load carried below dams will all promote increased vegetation colonization and/or succession. The riparian herbs and shrubs capable of withstanding frequent floodings and the process of sediment erosion/ deposition, will be replaced by species characteristic of more stable conditions. A portion of the mudflats and shrubby thickets that respectively provide food for waterbirds and moose could progressively be replaced by cottonwood, spruce or hemlock forests. These types are less productive in terms of wildlife. Early succession in newly formed or exposed mudflats will initially provide more food for wildlife, but within 10 or 20 years, less desirable plant species (for wildlife) should predominate.

The amount of secondary channels along the mainstems of the Stikine and Iskut rivers may be reduced as a result of lowered summer flows and other factors. These channels now provide rearing habitat for fish, waterfowl and beaver. Loss of wildlife habitat is therefore anticipated. Recreational access could be reduced as well, diminishing hunting and wildlife viewing opportunities. Islands that are now isolated may become connected to the mainland, and the associated open and early successional vegetation may progressively change to forested types. Breeding waterfowl, especially geese, and calving cow moose may suffer increased predation as a result.

Increased winter water flow and temperature may also affect wildlife. Preliminary data suggest that no ice cover would form below the dams, possibly as far down as the confluence of the Stikine and Iskut rivers. This would affect moose and wolves that use frozen rivers as movement corridors. Access to lower river areas by snowmobiles would be reduced during the winter. Increased disturbance of moose wintering populations could result, and potential or present trapping activities could be disturbed. Further study is required to determine the extent of the effect on trapping and whether this can be reduced by the use of boats. It is not known how the beaver populations occupying side channels could be affected by increased winter flows. It is possible that higher water levels may improve access to food caches.

The benthic invertebrates and other aquatic organisms found below the dams could be affected. A decline in the amount of organic matter available to the food chain, and lowered summer water temperature may slow organism growth. Reduced sediment transport could provide a more stable substrate for benthic organisms, but the increased daily fluctuations below regulated reservoirs were shown to decrease benthic diversity while increasing its biomass below the scour zone (Jackson, 1983). It is not possible now to estimate the likelihood and magnitude of such impacts, but if the lower organisms in the food chain were affected, fish, waterfowl and other wildlife species such as bears, seals, or bald eagles could be affected.

The seasonal redistribution of discharge, the reductions in flood magnitude and sediment budget may all contribute to an alteration of conditions in the Stikine estuary. Changes in the current rate of aggradation of the estuary, the penetration distance of salt water wedge in summer and winter, and the rate of nutrient delivery to the estuary may affect the maintenance and growth of the estuary marshes now used by fish, waterfowl and shorebirds. Again, the likelihood and magnitude of such impacts are not known at this point.

(ii) Generation Area (Area 2)

A detailed impact assessment for the generation projects was given by Blood and Anweiler (1982b). Specifics regarding wildlife populations and habitats in the different reservoirs are summarized here (Table 5-11) and overall impacts are discussed.

The kind of impacts expected as a result of generation development include permanent habitat loss due to reservoir flooding and the construction of permanent roads, damsites, townsites, etc. The Tanzilla reservoir would flood about 768 ha of wildlife habitat, most of which is aspen forest, rock or bare ground (Blood and Anweiler, 1982b). The Stikine Canyon reservoir would flood 10 400 ha of habitat of which 83 percent is forested by coniferous (46 percent), deciduous, or mixed wood species. The More Creek reservoir would flood about 3300 ha of which 59 percent is covered by alluvial forests. The Iskut Canyon reservoir would cover 2650 ha of which 43 percent are alluvial habitat types.

Habitat losses resulting from permanent roads and ancillary facilities, a total of less than 200 ha, would represent a small increment to the losses resulting from flooding. Estimates of wildlife impacts resulting from reservoir habitat losses and other factors (Table 5-11) show that most of the wildlife losses would be attributable to the Stikine Canyon project. Other project impacts on wildlife should be minor by comparison, although increased access and human populations in the area would require more intensive management and protection of wildlife.

After loss of habitat due to flooding, mortality resulting from increased human exploitation may be a major concern. Increased access by road or by boat and increased human population in the study area may result in heavier hunting and trapping pressure. This may be seen as positive or negative according to the ability of wildlife management agencies to control overexploitation of wildlife populations. Access to ungulate winter ranges, presently inaccessible, could be secured through the use of snow vehicles on the frozen reservoirs. Vulnerable populations of goats, moose, caribou and grizzly bears could be affected.

Habitat alterations could also affect wildlife. Slumping or erosion of land along reservoir shorelines would probably change vegetated habitats at those locations into bare substrate, changing the angle of the adjacent slopes. This could affect the goats and possibly moose that now feed on vegetation from these slopes. Vegetation removal along temporary access routes and sites would also alter habitat as a different type of vegetation would regrow after reclamation. Habitat overuse resulting from the displacement of animals from the reservoirs is possible, but should be temporary. Goat and moose populations in these areas may temporarily decline as a result.

Noise and other disturbances resulting from aerial and ground transportation, and from construction activities can provoke abandonment of localized habitats by wildlife. Direct harassment of animals, especially bears, is also possible. Disturbance of goats and raptors by aerial traffic, and vehicle/animal collisions are expected. Disturbance of goats around dam sites and construction areas can also be expected.

(iii) Transmission Corridor (Areas 2 and 3)

The building of the transmission line would involve clearing approximately 8800 ha of forest between the generation sites and the Telkwa Substation. However, it is difficult to quantify direct wildlife impacts along this corridor. The present vegetation, mostly dense coniferous forest, would be replaced by a shrub or grass cover. Wildlife species depending on mature forest types would lose some habitat, while species that require early successional types may benefit from the vegetation clearing. However, the extent of such benefits and losses is not known, and cannot be translated into a finite number of animals. Accordingly, impacts are defined in relation to project actions and rated as functions of expected extent and duration (Table 5-12).

Habitat losses and disturbance associated with pre-development and construction activities would have localized impacts on wildlife for a short period of time. On the other hand, the loss of habitat due to right-of-way clearing and the wildlife mortality associated with increased access could occur over the life of the project and have a regional impact. For certain wildlife species such as the mountain goat and grizzly bear, impacts may be significant at the provincial level.

By far, the major impact of the transmission corridor will result from providing access to wildlife populations that are now inaccessible and are vulnerable to human disturbance and hunting pressure. Access to new areas (1 km away or more from existing roads) could be provided along 216 km, i.e. 37 percent of the 587-km right-of-way. The grizzly bear (Areas 3, 8, 9, 10, 11 as given in Section 5.2.8(b)(iii) and located on Fig. 5-6), mountain goat (Areas 6, 12) and Stone sheep (Area 4) populations found along or adjacent to the proposed route are of special concern as these species have a low reproductive rate and poor tolerance to human disturbance. Habitat exclusion caused by human activity combined with increased mortality (resulting from vehicle collision and/or shooting) could reduce the populations now found in the area.

Construction activities during critical periods or through sensitive areas can be very disruptive to wildlife. Salmon-spawning creeks used by bears, calving and wintering range for ungulates, migration stops for waterfowl, and slow-meandering streams occupied by beavers are sensitive areas. The Hanna/Tintina creeks area is of special concern as a substation is planned for this site.

Moose (Areas 1, 2, 3, 5, 7, 8) and deer populations would be subjected to increased disturbance and hunting pressure. However, they could also benefit in some areas as a result of the project. The cleared right-of-way may provide forage species otherwise not available in the surrounding closed-canopy coniferous forests. However, vegetation control practices and excessive snow depths along the cleared right-of-way may cancel some of these benefits.

The cleared right-of-way may constitute a barrier to wildlife movements, especially when two or three lines paralleling one another necessitate a wide clearing. Ungulates such as moose (Joyal et al., 1984; Lamothe 1984), deer (Hydro Quebec, 1981; Chartrand et al., 1983) and caribou (Klein, 1971; Hanson, 1981) often hesitate to traverse large open areas or react adversely to foreign habitat features.

Positive impacts may also be observed (e.g. increased forage production) for certain wildlife species. This may last for the life of the project depending on the maintenance practices used to control right-of-way vegetation. In addition increased recreational hunting and trapping opportunities and revenues could be expected but these would depend on existing and new access and on hunting regulations. Increased harvests of wildlife which are viewed as a benefit from the harvesters perspective may be viewed negatively in terms of resource management. Also current trapping and guiding activities could also be negatively affected as the public now have access to formerly in accessible areas.

(d) Conclusions

(i) General

Appreciable wildlife losses will result from the flooding of the Stikine and Iskut valleys. Such losses cannot be avoided if the project is to proceed, and can only be compensated for. Wildlife losses attributable to downstream impacts, and the building of access roads, ancillary facilities and a transmission corridor cannot be quantified at this point but should be only a fraction of the losses resulting from flooding. A carefully designed mitigation program should alleviate many of these wildlife impacts and compensation packages should centre on the protection and management of wildlife populations in the affected areas.

(ii) Specific

A. Downstream (Area 1)

In Area 1, wintering moose in the floodplain of the Stikine River and migrating waterbirds in the estuary are the major wildlife affected. Possible habitat alterations, such as a shifting of early successional vegetation to more mature forested types and reduction of side channel length on the mainstems of the Stikine and Iskut rivers, or a change in area and vegetation composition of the estuary tidal marshes, could eventually affect these populations. More detailed information on wildlife populations and their relationship to their physical environment in Area 1 is needed before impacts can be assessed and any necessary mitigation measures defined.

B. Generation Area (Area 2)

In Area 2, major wildlife impacts will result from the flooding of at least 17 000 ha of habitat. As many as 120 moose, 55 goats, 65 black bears and 15 grizzly bears, and numerous furbearers and birds will be displaced by the proposed reservoirs. Incremental impacts resulting from transmission line construction and the building of ancillary facilities are minor compared to these habitat and population losses. The project will also provide permanent access to wildlife populations that are now largely inaccessible, offering greater wildlife viewing opportunities but also allowing increased hunting and poaching. The goat, caribou and grizzly bear populations are especially vulnerable. Little mitigation is possible for the losses resulting from flooding. However, impacts resulting from construction activities, facilities location, and increased access can be mitigated. Compensation for non-mitigable losses should be defined in collaboration with the provincial wildlife management agency.

C. Transmission Corridor (Areas 2 and 3)

In Areas 2 and 3, the location of a transmission corridor would involve the clearing of roughly 8800 ha of forested land and its subsequent maintenance to a grass or shrub cover. At least a third of the 587-km line would provide access to areas currently not accessible. The impacts of habitat alteration and new access on the wildlife populations found along the transmission right-of-way are difficult to quantify. Moose and deer may benefit from the vegetation clearing, but along with goat, sheep, bear and furbearer populations may suffer as a result of increased hunting or trapping. The major mitigation recommended is one of avoidance. The building of the transmission line near important wildlife ranges, such as the Hanna/Tintina creeks area, or during critical seasons (e.g. calving or winter time) should be carefully controlled. Access to the cleared right-of-way during and after construction should be carefully controlled so as to protect vulnerable wildlife populations and optimize their management by wildlife agencies. Further detailed studies are needed to assess specific impacts, mitigation measures and commensurate compensation.

5.2.9 Recreation

(a) Studies Completed

The impacts of the project on the recreation and tourism resources of the study area have been examined in two separate studies carried out between 1979 and 1983. A recreation and tourism impact study of the hydroelectric developments on the Stikine and Iskut rivers was undertaken by DPA Consulting (1982). DPA's impact assessment included evaluation of changes in the recreational capability of the study area, changes in the future patterns of recreational use in the area and changes in the amount of recreational benefits provided by the region. The study area included both the Stikine and Iskut projects.

DPA's recreation and tourism study used a number of methods to evaluate the nature and use of the resource.

1. Field inventory and classification of recreation resources and facilities.

2. Field survey of recreational use during August and September 1980.

3. Consultation with government ministries and local residents to gather available statistics on recreation activities.

On the basis of the information gathered by the above methods, current recreation activity was estimated by type and user group. In addition, four use scenarios without the project and four with the project were developed, and projections were made of future recreation and tourism demands to determine project impacts for the alternative futures for the study area.

A comparative assessment of the impacts of transmission facilities along candidate corridors was completed by John Thomas and Associates (Hayward, 1982). The study examined a large number of corridors at an overview level and the results were used to select corridors for further detailed study. The study was based on an aerial reconnaissance of corridors and assessed the potential impacts on recreational resources and features, facilities and use. Interviews with personnel in provincial, regional and municipal agencies were also conducted to establish recreational potential of the study areas. Recreation impacts were rated from severe to slight and used in the overall preliminary impact assessment.

When the preferred route and alternatives were selected in the Preliminary Planning report, a further assessment was made based on the preferred route as part of the interim assessment of the entire Stikine-Iskut development. This assessment rated potential impacts on recreation resources and uses with respect to the proposed route and right-of-way. In addition, plans for recreational developments and facilities known to the Ministry of Lands, Parks and Housing were also reviewed with respect to the transmission route.

An additional study, of the value placed on recreational resources in the project area by potential users, was contemplated. However, it was not carried out due to difficulties with establishing an appropriate study method.

Neither of the studies undertaken addressed changes downstream of the project (Area 1). Such an evaluation was held in abeyance pending clarification of physical changes.

(b) Resource Inventory

The following is a summary list of major outdoor recreation features in this area.

1. Grand Canyon of the Stikine and tributary canyons (aesthetics).

2. Upper Stikine River (fishing and boating).

3. Beggerlay Creek (fishing and boating).

4. Eddontenajon, Ealue, Kluachon, Morchuea, Island, Devil and Bob Quinn lakes (fishing and boating).

5. Klastline Plateau and Spatsizi Plateau (wilderness recreation).

6. Forrest Kerr Creek headwaters (wilderness camping, glacial features).

7. Newmont Lake upland and Tom Mackay Lake upland (wilderness camping, fishing).

8. More Creek mouth (canyon features, wilderness, camping, fishing).

9. Lower Iskut River (wildlife viewing, boating, fishing).

Based on results of the survey and consultations, it was estimated that in Area 2 the annual, general recreation currently totals 34 656 user-days. When hunting and fishing were added, the total was estimated at 73 261 user-days by 12 386 recreationists. About 20 percent of the present recreation activity is done by study area residents, 50 percent by B.C. residents outside the study area, and 25 percent by non-B.C. residents.

The inventory of recreation resources for the transmission corridor in Area 2 identified a number of recreation features that could be affected by the transmission route. These included Kinaskan, Eddontenajon, Ealue, and Bob Quinn lakes, Cascade Falls, and the Stikine Canyon.

Along the transmission route to Telkwa Substation (Area 3) the recreation value originates from the scenic backdrop to Highway 37. While the area is not well developed in terms of established facilities, the scenic potential is high along riverbanks and lakeshores in the corridor.

Areas with high recreation potential in the study area are:

- Meziadin Lake
- Swan Lakes - Brown Bear Lake region
- Kitwanga Lake
- Skeena Crossing
- Bulkley River near Telkwa

A recreational subdivision has been developed on Meziadin Lake and a park has been proposed for the same area. Highway 37 provides access to viewing, camping and fishing in the Kitwanga Lake area but generally between Meziadin and Skeena the recreation potential in the area is not well developed. Further south in the upper reaches of the Zymoetz River, near Dennis/Aldrich and Hankin lakes, Hudson Bay Mountain and the Telkwa River have a variety of facilities; recreation intensity varies with the ski area on Hudson Bay Mountain being heavily utilized.

The locations of existing and proposed Parks and Recreation Areas are shown on Fig. 5-8.

(c) Impact Assessment

(i) Area 2 - Generation and Transmission

A. Impact on Recreation Resources

The anticipated losses of significant recreation resources are as follows:

1. Portions of the Grand Canyon of the Stikine, particularly the 15 km of the canyon associated with the Stikine Canyon and Tanzilla reservoirs. This is the most significant permanent recreation and visual loss as the canyon is considered to be unique by provincial if not national standards. The Grand Canyon downstream of the Tanzilla project would remain undisturbed.

2. The upper Stikine River including the lower part of tributary streams, Beggerlay Creek, McBride River, and the lower Klappan River would be inundated. The potential of the inundated areas as high quality recreation areas for fishing, boating and hiking would be lost.

3. Eddontenajon Lake and Bob Quinn Lake, both important accessible recreation areas for fishing and boating, will be indirectly affected by the visual impact of the transmission line. While this impact will not eliminate any recreation facilities, the wilderness setting will be altered so as to impair the quality of the resource.

4. A portion of the scenic Forest Kerr headwaters with high elevation camping potential would be inundated.

5. Iskut River drainage, including More Creek would be affected, however this area has only moderate potential as an outdoor recreation site.

The consultant study also identified the following positive impacts of the development:

1. The hydroelectric facilities themselves will be an attraction and would stimulate tourism in the region.

2. The Stikine reservoir would provide boating access to the Pitman and Spatsizi rivers. In addition, the Tanzilla reservoir would provide boating and canyon viewing opportunities in an otherwise unnavigable canyon, which is largely inaccessible.

3. Road access would be provided to recreational and scenic areas such as the Stikine and Iskut canyons, presently inaccessible lakes in the Bob Quinn and Devil lakes area, and lower More Creek.

B. Impact on Recreational Use in Generation Project Area

Scenarios were used to estimate the number of total recreation days in the study area, assuming that the hydroelectric development was not built. Using growth rates in recreation user-days between 2.6 percent and 5.1 percent, and similar recreation participation rates to other sections of the province, total use was projected to be 200 000 to 275 000 total user days by the year 2010.

With the hydroelectric development for the same time periods, projections to 2010 were 3 to 5 percent lower than without development scenarios which is within the accuracy of such projections.

(ii) Area 3 - Transmission

With careful route planning, transmission line construction would not result in any actual loss of recreation resources, since most outdoor recreation activities may be carried out in their vicinity. Most impacts of the transmission line are primarily visual.

The main impacts along the route would be as follows:

km 0 to 20:	Indirect impacts on recreational potential Bob Quinn Lake, Ningunsaw River and the Bob Quinn Ecological Reserve.
km 102:	Bell-Irving River crossing, a popular fishing spot; view would be affected by cleared right-of-way.
km 165 to 180:	Right-of-way may affect recreational access to Swan Lake.
km 205 to 240:	Visual impacts would influence the recreational potential of Cranberry Valley and Kitwanga Lake.
km 272:	Visual impacts at Skeena Crossing.

km 305:	New right-of-way and associated access roads would provide recreational access to Kitseguecla River headwaters area.
km 325:	View from Hudson Bay Mountain recreation area would be affected.

In all cases potential impacts are related to loss or degradation of the natural setting, but would not result in direct loss of recreation resources or use.

5.2.10 Visual Resources

(a) Studies Completed

In 1979 Life Space Designs Ltd., Vancouver carried out a visual analysis of the proposed Stikine River projects. The objective of this analysis was to assess the impact of the hydroelectric development on views of the Stikine River and to evaluate the scenic significance of the Grand Canyon of the Stikine River within Canada and North America.

Their report (Life Space Designs, 1981a) illustrates the visual impact that construction of the project would have on the Stikine valley through the use of retouched photographs and a comparison of the scenic quality of the Stikine Canyon with 12 other remarkable river canyons in North America. This work considered the Stikine River projects alone; assessment of the Iskut projects is intended to be undertaken in the future.

The photographic inventory consisted of a series of aerial oblique photographs of the study area. These were later touched up with the reservoir levels, simulating the appearance of the valley and canyons with the reservoir at full pool. Following the principles developed in the Visual Resources of the Northwest Coal Study Area (Tetlow & Sheppard, 1977), the study area was divided into "visual units" or areas in which the landscape is similar in appearance. These visual units were then scored for scenic distinction according to scenic values identified in studies by Tetlow & Sheppard as well as Leopold (Leopold, 1969). The visual units were scored for scenic distinction both with and without the project, based on the simulation of reservoirs on valley and canyon photographs.

Comparison of the scenic values of the Stikine Canyon with selected river canyons in North America was done with information from Parks Canada, and a study comparing river landscapes in the U.S. by Leopold. The canyons were compared according to a technique developed by Leopold that determines a quotient of physical, visual and human interest factors and compares their unique features.

The visual sensitivity and visual resources of a large part of northwestern British Columbia were considered in the study of corridor options in the preliminary assessment of the transmission system (Life Space Designs Ltd., 1981b). The preferred corridor(s) was chosen as a result of the evaluations of all the environmental disciplines and technical feasibility made in the preliminary assessment (Hayward, 1982). The preliminary assessment of visual resources rated the scenic distinction of corridor sectors. Further, detailed study of selected corridor(s) would define the visual characteristics of the transmission facilities using smaller visual units and determine those areas where transmission lines and rights-of-way would be visible from the existing roadway. Because of a reduced study program, this interim assessment indicates the portions of the proposed route that are visible from Highway 37, using the scenic distinction rating of the preliminary work. Since Highway 37 has been designated as a "wilderness" highway by the Ministry of Transport, the visual impact of the transmission line and right-of-way on viewers is a key consideration in the assessment of impact.

(b) Summary of the Resource

Study region 2 of the proposed Stikine-Iskut Development is located in northwestern British Columbia, a region noted for the vast wilderness, splendid mountain scenery, and wild rivers. The generation projects would directly affect two major river systems while the associated transmission lines would traverse an extensive untouched wilderness. The Grand Canyon of the Stikine has been noted as one of the scenic wonders of the Pacific northwest of the continent and as an area of wild river scenery that may be worthy of national interest and designation.

Scenic distinction scores for the three visual units of the Stikine valley affected by the hydroelectric development are shown on Table 5-13. According to the scenic distinction factors chosen, the Grand Canyon unit is the most distinct of the three, largely because of the river's form, character, and spatial vividness. Out of a possible score of 200, the Grand Canyon was given 89, signifying a high degree of scenic distinction. The other two units, Klappan and Upper Stikine rivers, were rated as having moderate (43) or low (38) scenic distinction, respectively.

The comparison of relative uniqueness quotients of selected rivers in North America (Table 5-14) illustrates that the Stikine Canyon is comparable to a sample of 13 of the most remarkable river canyons in North America.

The transmission corridors were also categorized according to scenic distinction and the route was assessed according to its visibility from the road. Results are shown on Tables 5-15 and 5-16 for Areas 2 and 3 respectively.

(c) Impact Assessment

Without the Stikine-Iskut hydroelectric development there would be little if any impact on the visual resources of the Stikine and Iskut valleys. They would remain as wild rivers in an untouched wilderness valley for the foreseeable future assuming there was no other major developments in the region. Similarly, there would be little visual disturbance to the Highway 37 corridor on the same scale as the transmission right-of-way.

If the Stikine-Iskut hydroelectric development were to take place, there would be a fundamental change in the scenery of the Stikine River in the development areas, changing it from a river to lake environment. This would affect the factors that comprise scenic distinction, resulting in a decrease in total scenic distinction score for the Grand Canyon visual unit. For the Klappan and upper Stikine visual units there is no appreciable difference in visual quality with the project according to this methodology.

There was no comparison made of the Stikine Canyon with the project to other river canyons in this analysis. Consequently, there is no assessment as to how the post-project Stikine Canyon would compare to the sample of canyons used in the comparison of uniqueness ratios.

Roughly one-third of the 216 km of transmission right-of-way in Area 2 will be visible to a motorist on Highway 37. The transmission right-of-way will be visible either in distant or close-up views for 61 of the 130 km (46 percent) from Bob Quinn to the Highway 37 crossing of the Stikine River. While the impact of the different views of the line will vary depending on direction of travel and many other variables, the recurring visual intrusion in a remote and vast area will permanently change the visual character of the region as seen by the majority of motorists and visitors.

The route from the Bob Quinn collector to Telkwa Substation (Area 3) covers a total of 373 km. Of this, 86 km or 23 percent of the route is visible from the main travelled routes primarily from Highway 37, but also from a short section of Highway 16 (see Fig. 5-7). In addition an 11 km segment is highly visible from the Hudson Bay Mountain ski area which is also considered a viewer sensitive area.

The right-of-way would be most visible within the sectors that are scenically most distinct or outstanding. Half of the route is visible from the highway in the Snowbank/ Ningunsaw River Pass and Cranberry River-Kitwanga Lake valley, areas that are also scenically spectacular because of the topography, vegetation patterns, and spatial vividness of the valleys (Life Space Designs, 1981). It is these same features that create a landscape that is vulnerable to visual impacts.

Conversely, areas that are considered of low scenic distinction (Meziadin to Swan lakes) would have very little visible impact with respect to the view from the highway. It follows that mitigation of visual impacts, while most important in highly scenic areas, are also much more difficult to implement successfully.

The key long-term impact to study area 3 with the development would be to radically change the visual impression of the countryside from Highway 37, thereby affecting the "wilderness highway" theme endorsed by the Ministry of Lands Parks and Housing for development of the route. Even with mitigation of impacts of the present route, over one-third of the total transmission right-of-way will be visible from heavily travelled highways. Of the 280 km drive along Highway 37 between Kitwanga and Bob Quinn Lake, an estimated 29 percent will be within view of the proposed transmission route, resulting in a long-term visual impact on the region. Site-specific and local visual impacts will be largely in the Snowbank

Creek-Ningunsaw Pass areas and the Cranberry River-Kitwanga valley, where views of the transmission line will be frequent and at close range in an otherwise highly attractive setting.

(d) Conclusions

The study indicates that according to the criteria used for visual distinction, the hydroelectric project would reduce the visual quality of the Stikine Canyon area but not the Klappan and the upper Stikine valleys. The study also indicated that the Stikine Canyon is comparable in visual quality to 13 of the more remarkable river canyons in North America, making this reduced visual quality a loss of provincial significance. The project would clearly alter the nature of the canyon, but the analysis did not go so far as to attempt a comparison of these other North American canyons to an altered Stikine Canyon.

The transmission lines would affect the visual impression of northwest B.C. wilderness as seen by travellers along Highway 37.

A regional long-term effect on the visual character of parts of the region is part of the social cost of the project. Although only a small portion of the entire route will be visible from the highway, the most frequent visibility of the right-of-way will be along the most scenic sections. Mitigation through rerouting and vegetation management would help to lessen the impacts in critical areas, but the overall impact will remain.

5.2.11 Heritage

(a) Studies Completed

Heritage studies for the Stikine-Iskut Development were initiated in 1979. Studies of those areas affected by the generation component of the project are complete, whereas, those for transmission are complete to the overview level required for the comparative selection of corridors.

A judgemental and stratified random sample inventory of heritage sites within the proposed reservoir boundaries was conducted in the field during 1979 (Aresco, 1980). This was followed in 1980 and 1981 by further sampling within the reservoir boundaries and in areas of anticipated ancillary development. An inventory of heritage buildings in the town of Telegraph Creek was also completed (Aresco, 1982a, 1982b). Additional judgemental inventory work within areas of ancillary development and exploration was completed during the 1982 field season (Aresco, 1983). In 1983, a final judgemental inventory and evaluation of the project area was completed and a summary report compiled (Wilson Consulting, 1984).

Evaluation of prehistoric heritage sites was aided by the results of archaeological test excavations, utilizing 1 m^2 test units at each site examined. Standard analytical procedures were applied to the results of archaeological excavations. This included analysis of artifacts, cultural features (fire hearths, etc.), stratigraphy and radio-carbon date estimates. Special attention was given to the analysis of faunal remains (animal bones) found in excavated sites as this procedure is very helpful in determining prehistoric diet preferences, animal resource utilization, site activities and the season of site occupation.

Data from both the site inventory aspect of field work and from test excavations, was utilized in arriving at individual site significance. The criteria applied to the site evaluation scheme were those contained in the Heritage Conservation Branch's document, entitled Guidelines for Heritage Impact Assessment in British Columbia (1983) (Government of B.C., 1983).

The inventory of heritage buildings in Telegraph Creek was accomplished by means of visual observation, discussions with local residents and the compilation of a photographic record. Individual buildings were evaluated for heritage significance on the basis of criteria developed by Parks Canada (Kalman, 1980).

Overview heritage studies for the transmission component were undertaken in 1981 (Points West Heritage Consulting, 1981). The study was completed without field work and was based on existing site inventory data, relevant publications, reports, manuscripts, archival research, map and aerial photographs and consultation with other researchers who had worked in the study area. The information collected was used in the multidisciplinary selection of preferred corridors. A second study was undertaken (Points West Heritage Consulting, 1983) which concentrated on the selected corridors and redefined the potential rating scheme for heritage resources in these corridors. Areas of heritage potential were ranked and mapped based on three criteria, namely, availability of resources, (e.g. food), accessibility and landforms.

(b) Resource Summary

(i) Downstream (Area 1)

The heritage resource inventory for Area 1 resulted in the identification of seven buildings in Telegraph Creek with historic importance:

1. The Riversong Cafe is an old Hudson's Bay store which has been moved from Glenora to Telegraph Creek. This building probably dates from the 1920s.

2. St. Aidan Anglican Church was completed in 1924. It is wood structure and has a number of interesting architectural details.

3. The Roman Catholic Church appears to be a converted log house. It is a unique building with several outstanding construction details.

4. The Roman Catholic Rectory is an interesting building featuring a hip roof with dormers. This building represents a rare architectural form in the community.

5. The B.C. Telephone Building is now used as a storehouse for a river excursion business. It is of log construction featuring dado corner joints.

6. The Stikine Hotel Annex is all that remains of the Stikine Hotel which was once located on the river front. The annex was used as a hunters' lodge and has a unique architectural style.

7. J.F. Callbreath Pioneer Outfitter building's exterior has been well preserved. This building was apparently constructed in the 1890s and has definite historical associations with regional developments.

(ii) Generation Area (Area 2)

A. Reservoir

In Area 2, fifteen heritage resource sites have been recorded within reservoir boundary areas. Of this total, four are prehistoric in age and represent native occupation and resource utilization activities. Twelve heritage resource areas are from the historic period and are primarily associated with hunting and trapping activity in the area. (Site IaTm 1 contains both prehistoric and historic characteristics.)

The prehistoric and historic site characteristics are summarized in Table 5-17 and Table 5-18.

All historic sites found along the Stikine River (Area 2) are within 100 m of the existing river bank on well-drained level terrain. All sites are estimated to be between 30 and 70 years old based on degree of site preservation, construction techniques and materials utilized as well as presence/ absence of bottles, cans, inscriptions, newspapers, etc. All are associated with hunting, trapping and guiding activities as indicated by such features as tree caches, tent frames, hearths, dog houses, hide stretchers and traps.

Using evaluative criteria categories of scientific significance, historic significance, economic significance, and integrity/condition, all historic sites along the Stikine are considered of low value. However, of potential ethnic and local historic interest is site IaTl 4, the possible refuge for a Jewish family in World War II.

All historic sites along the Klappan River are located within 130 m of the present shoreline. Using the same criteria for significance as detailed for sites on the Stikine, the Klappan River historic sites are judged to be of low significance. However, HkTj 3 may be important in terms of ethnic and religious significance.

A summary description of each site appears in Table 5-18.

B. Ancillary Development Areas

One heritage resource site is located in the proposed ancillary development areas. The site, IaTn 1, is situated on the Stikine Plateau overlooking the Grand Canyon of the Stikine River near a helicopter landing pad. A description is included in Table 5-19.

C. Material Exploration Areas

A total of 15 heritage resource sites were recorded in the various material exploration areas. The nature of each site is described in Table 5-19.

The corridor between the generation sites and Bob Quinn collector (Area 2) contains 18 recorded heritage sites. Additional sites have been reported but not verified near Latham Creek and near Eddontenajon Lake. The historic Telegraph Trail is located along this corridor; the potential exists for several presently unknown sites along this trail and elsewhere in the corridor.

(iii) Transmission Corridor (Area 3)

In Area 3, a total of 19 previously recorded heritage sites occur along the wider corridor within which the transmission line route would lie. A large number of additional sites, yet to be located, are predicted to occur on the basis of the results of the 1983 heritage assessment study (Points West Heritage Consulting, 1983).

(c) Impact Assessment

(i) The Status of the Resource Base Without Project

A. Downstream (Area 1)

In Area 1, the condition of the heritage buildings in Telegraph Creek are generally rated as excellent. In the future these buildings would be vulnerable to possible physical decay and/or alteration by owners.

B. Generation Area (Area 2)

To date, 39 heritage resource sites are known in the Stikine-Iskut development area (Area 2). The majority (22) have been or are being disturbed to some degree. Three of these are due to Hydro related exploration activity. Degree of disturbance estimates are not provided as the area and volume of most sites are not known because of a lack of objective data from intensive test excavations.

Of the 22 sites, six have been affected by non-recurring activities such as fire, railway construction and bulldozers. Sixteen sites are subject to recurring impacts such as erosion, physical decay, recreation and trail building.

C. Transmission Line Corridor (Areas 2 and 3)

No work has been done to identify the status of the resource base without the project in the areas affected by transmission lines.

(ii) Status of the Resource Base With Project

A. Downstream (Area 1)

In Area 1, there may be changes to the Heritage Buildings in Telegraph Creek as a result of residents upgrading their present housing and services to facilitate greater use of the town. Any resulting impacts cannot be quantified or predicted with any degree of confidence.

B. Generation Area (Area 2)

In the area of the generation projects, Area 2, the types of impacts expected in each project stage are detailed below:

Exploration Stage

For the Stikine-Iskut development, only direct impacts are expected in this initial stage. Direct impacts have occurred at HlTm 1 as a result of the B.C. Hydro drilling program designed to locate suitable gravel sources for construction and Site HlTm 4 has been disturbed by a cattrail and recreational use. Site IaTn 1 has been disturbed by a helicopter pad.

Construction Stage

The major impacts to heritage resources will occur during the construction stage. Studies to date indicate that most heritage sites occur in areas that would be altered by the clearing and construction of reservoirs, access roads and borrow areas.

Direct Impacts

Of the known resource base, 15 sites fall within the area that would be flooded by reservoir creation. Clearcutting of timber would likely occur in this reservoir zone, thus potentially affecting these 15 sites prior to flooding.

No heritage sites identified to date would be affected adversely by damsite construction or by ancillary developments.

Fifteen sites are known within areas identified as possible sources of gravel in Tanzilla Area 14 and Morchuea Lake Areas B and B1.

Indirect Impacts

Site HlTm 4 could be impacted by the upgrading of an existing Forest Service campsite at this location. However, the mitigation of this conflict is not the responsibility of B.C. Hydro.

No conflicts of heritage resources with the realignment of Highway 37 have been identified.

Other Impacts

With the influx of a large workforce combined with improved access, the study area sites would likely experience some level of unlicensed artifact collecting. Presently, such activities are minimal.

Operation Stage

The impacts expected during this stage are largely direct impacts as a result of reservoir creation and subsequent shoreline alteration. No areas of impact from slope instability were identified for the More Creek or Iskut Canyon projects. However, several small areas along the Stikine Canyon and Tanzilla sites have high heritage resource potential and may be subject to sloughing. Minor additional field investigation would be required.

There is also some evidence to suggest that site vandalism, particularly in the vicinity of reservoir shorelines may be intensified (Lenihan et al., 1978; Mohs, 1977).

Along the transmission route between the generation sites and Bob Quinn collector, there would be no impacts on presently recorded sites. However, the route does cross several areas which are rated as having high or moderate potential for heritage resources (Points West Heritage Consulting Ltd., 1983). Along the balance of the transmission route to Telkwa Substation (Area 3), the route passes within a kilometre of two recorded sites designated as GjTbH 2 and GjTcH 2. Both of these sites are near the Cranberry River north of Kitwanga Lake.

The route also traverses areas which are rated as having high or moderate potential for heritage resources (Points West Heritage Consulting, 1983).

While it is not known at this stage whether or not heritage resources would be encountered, it is worth noting that B.C. Hydro has in place standard procedures for protecting such sites. These include:

1. Locating of access roads, work areas, towers etc., to avoid heritage site;
2. installing flagging, staking, fencing and other protective measures around designated sites.
3. application of hand clearing techniques or other non-destructive clearing methods in areas of heritage resources;
4. special collections and/or archaeological excavations of all or portion of highly significant heritage site(s).

It should be noted that the last mitigation option is seldom exercised, as most conflicts can be resolved by the application of one or more of the other options.

(d) Conclusions

With appropriate mitigation, the generation component of the development will not result in significant heritage resource impacts. Moreover, the costs of mitigation and compensation are expected to be low. Although transmission line studies are incomplete, the preliminary data suggest that few heritage conflicts are likely for that component as well.

5.2.12 Land Use

The purpose of land use studies within the environmental and socio-economic assessment is to assess the impact of the development on present land tenure and use as well as implications for future land use and land use planning.

(a) Studies Completed

Land use studies of the Stikine-Iskut project have been underway since 1979. Three major studies were undertaken.

A land use and status inventory was completed in 1980 and updated in 1982 to serve as a basis for other studies by describing the ownership and status of lands in the reservoir and surrounding areas (B.C. Hydro, 1980/82). The inventory describes flood reserves, Crown lands, Crown-granted lands, Indian reserves, forestry tenure, wildlife harvesting territories, various reserves, mineral leases and water licences. Land status information was obtained from Provincial Government Lands Branch records.

As part of the transmission preliminary assessment, all reserves, alienated lands, rivers, and water licences in the corridor under study were mapped (Hayward, 1982). In addition, the report made general statements concerning land use plans and land use potential in the corridors and in the immediate vicinity.

The general land use study by the Eikos Group (1983) compared the land requirements of the project to land impacts described in environmental studies. Most significantly, this report attempts to predict broad changes to land use in the region that would be caused by the project, its facilities and access roads.

Discussions with staff of provincial government ministries, regional districts and municipalities were held concerning future developments in both generation (Eikos) and transmission (Hayward) studies.

(b) Summary of Land Tenure, Use and Planning

A summary of location and areas of private lands directly affected by both the generation and transmission projects are shown in Table 5-20 and Fig. 5-8.

With the exception of privately held lands west of Telkwa substation and some isolated parcels along the transmission route and reservoir area, the featured development will only alienate crown owned land. In addition, there are a number of interests (Table 5-20) on the land as expressed through crown land reserves (mostly held by B.C. Hydro), timber sale licences, traplines, guiding territories, grazing permits that may also require compensation for termination or otherwise affecting these interests.

(c) Impact Assessment

Almost all land required for the project is crown land with the following exceptions:

1. Eleven hectares of private land in agricultural use would be inundated by the Stikine Canyon reservoir.

2. Transmission lines would cross private land parcels at Todagin Creek, Skeena River crossing, Moonlit Creek near Kitwanga Lake, Dennis Lake.

3. Transmission lines would also cross an undetermined number of private land parcels in the 24 km west of Telkwa substation.

A complete summary of interests on crown land along the transmission route was not completed for this report.

While there are no comprehensive regional land use plans in effect, government ministries, municipalities, and regional districts have plans and policies with regard to land use that have been considered in the General Land Use Studies (Eikos, 1983).

Future land use as expressed by government policies and plans indicate that, in addition to the proposed B.C. Hydro development, there are other possible economic and social developments in the region that will influence the character and pattern of land use in the area. These are:

1. A highly developed tourism and outdoor recreation industry based on the spectacular scenery and wilderness character of the area is planned by some. Such a scenario would require land use planning that maintains the wilderness character of the area and careful development of tourism and recreation facilities along Hwy 37 (Fig. 5-8).

2. Development of major metal and coal mines in the region would require lands for transportation, settlement and energy facilities.

3. Maintenance of existing resource economy and lifestyle would require maintaining the wilderness character of lands in order that fishing, trapping, hunting and guiding will continue to have a renewable resource.

With adequate land use planning, the hydroelectric development should be compatible with these other development scenarios.

(d) Conclusions

The Stikine-Iskut development would require approximately 30 000 ha of land (plus the area associated with ancillary facilities) (Table 5-20). For the most part, the development would occur on undeveloped Crown land.

5.3 SOCIO-ECONOMIC STUDIES

5.3.1 Background of Studies

(a) Overview

From a socio-economic perspective, the Stikine-Iskut development is extremely complex. The development contains many factors which contribute to potential impacts.

1. It is a large project both in terms of amount of land affected and number of installations.

2. A large work force will be required during construction.

3. The activity is intense and of limited duration.

4. The development is in an isolated area.

5. The local population is small and dispersed.

6. The local residents have low mobility.

7. The local economy is primarily non-industrial.

8. Many of the local residents have a different value system from the industrialized southern part of the province.

As well, the project has some unusual characteristics. Because Highway 37 is the only major access, there is a channelling effect between the local project area and the regional area to the south. Not only does this increase the probability of impacts related to the generation segment of the project in relatively distant places but these same areas are also on the transmission corridor. There is then a high degree of integration between impacts related to the generation and transmission segments of the project.

(b) Studies History

(i) General

Socio-economic studies for this development are not complete. Further information is required on communities in the generation and transmission areas, especially native communities. Some contacts have been made in these communities and some information has been exchanged. However, to date native groups have been reluctant to participate in socio-economic studies under the direction of B.C. Hydro. As a result, baseline data for this interim assessment is limited.

(ii) B.C. Hydro Socio-economic Studies

To date, two studies have been undertaken; one related to the generation component and one to transmission.

Generation - Limited discussions between B.C. Hydro and local residents began in 1976. A study undertaken by Canadian Resourcecon (1982) was commissioned in 1979 to examine the implications of the generation component of the project. The study identified community structure and function and speculated on the impacts of the development in this area.

The examination of impacts in the regional area was limited to a few factors and four communities.

Transmission - The transmission-related study prepared by DPA Consultants (1981). was part of a larger integrated team approach to the transmission corridor selection process. The study was a cursory examination of the socio-economic concerns over a wide area which included all possible corridors. Little local involvement was obtained.

Study Methods - Both the Canadian Resourcecon and DPA Consulting Ltd. used a combination of secondary source information and direct interviews. In these studies a variety of published and unpublished sources were consulted to assemble an inventory of present conditions in the region and construct future development scenarios. Published information about existing social and economic conditions in the immediate study area was limited. There was little direct interaction with residents in the communities.

Recognizing the need for a more thorough socio-economic study terms of reference were developed in the Spring of 1983. Attempts were made to involve native groups in the development and execution of this work. However, due to changes in the Stikine-Iskut Development schedule this new socio-economic study never proceeded. If the project is reactivated, these Terms of Reference would be useful as a basis for developing a new study process.

(iii) Other Related Studies

Two other studies have been undertaken which relate closely to socio-economic concerns in this area:

1. The Northwest Region - A British Columbia Regional Economic Study 1982. (Province of British Columbia, 1982.)

   This was prepared as a preliminary report outlining the possible economic developments, the energy requirement, and the transportation system in the Northwest.

2. Stikine-Iskut Development - Report on Stage I Settlement Studies October 1982, amended May 1984 - (B.C. Hydro, 1984(c)).

   This report provides an interim assessment of settlement requirements for the Stikine-Iskut Development.

(c) Objectives

There were four major objectives to the socio-economic assessment process for this development.

1. To determine the socio-economic impacts.

2. To determine mitigation measures needed to reduce/avoid adverse impacts.

3. To assist local residents to understand the implications of the project and provide necessary information for local and regional planning to accommodate changes and opportunities induced by the project.

4. To develop a monitoring and management process which could identify unanticipated impacts, compare actual impacts to predicted impacts, and establish a process for managing these impacts.

(d) Assumptions

The results reported below are based on the assumption that there would be:

1. No significant development in the area prior to the Stikine-Iskut development.

2. No significant area development during or immediately following construction of the project.

3. A settlement as described in the Stage I Settlement Report.

5.3.2 Results

(a) Regional Characteristics - Overview

Settlement in the northwest is concentrated in the southern part of the study region near the Highway 16 corridor from Houston to the coast. North of Stewart, there is very little development and the settlements are isolated. The study region is shown in Fig. 5-9.

Population figures were collected for an area called the northwest region (Province of British Columbia, 1982). The northwest is similar to the study region but it includes Kitimat and excludes Smithers, Telkwa and Houston.

According to the Northwest Report (Province of British Columbia, 1982), the total population in 1981 was 62 755, an increase of about 60 percent since 1961. In the Kitimat-Stikine Regional District the population increased 84 percent (23 031 to 42 400) while the region of Stikine grew by 60 percent (1 224 to 1 953) over the same 20-year period. However, growth in the decade 1961 to 1971 was almost three times as large as the decade 1971 to 1981.

It has been estimated that in the northwest region, 20 percent to 25 percent of the population are Native Indians (combining status and non-status), about half of which live on reserves.

In the area as a whole, the forest industry is the dominant source of economic activity. Logging is carried out in most parts of the area that are within reach of the Highway 16 - CNR corridor, along which sawmill operations are concentrated. There are mineral deposits with development potential in many parts of the region, and in the early 1980's there were producing mines at Stewart, Cassiar, Houston, Kitsault and Baker Lake. The agriculture sector is important in the Bulkley River Valley, the Skeena River Valley from Terrace to Hazelton, and the lower reaches of the Kispiox River. Manufacturing is mainly limited to sawmill operations.

Fishing is a predominant industry on the coast. Although the economy will remain resource-oriented in the foreseeable future, there are indications of some diversification of the economic base.

Two major highways transect the region with Highway 16 acting as the main east-west corridor linking Telkwa, Smithers, Moricetown, New Hazelton, South Hazelton and Terrace. Highway 37 serves the north-south route. On this highway lies Kitwanga, Meziadin Junction, Tattogga Lake, Eddontenajon, Iskut, Dease Lake and Cassiar.

The Canadian National Railways parallels Highway 16 and is the major rail route in the region.

The study region is served by the three ports at Prince Rupert, Kitimat and Stewart.

Terrace, Smithers, Prince George and Prince Rupert are served by major airlines while Kitsault, Telegraph Creek, Iskut and Dease

Lake are served by regional airlines. There are also a number of smaller airline and helicopter companies in the region that operate primarily on a charter and contract basis.

The Stikine-Iskut Development would affect residents in two Regional Districts, the Bulkley-Nechako and the Kitimat Stikine. The unincorporated region of Stikine is also in the project area.

Federally, the project would have influence in two constituencies, Skeena (NDP) and Prince George-Bulkley Valley (Conservative). Provincially, five constituencies are within the project region, two held by Social Credit, two by the NDP, and one by an independent.

Much of the land area in northwestern B.C. is included in tribal land claims based on aboriginal title. There have never been any treaties signed in the region.

The Indian Claims Commission Office in Ottawa has accepted four claims for negotiation within the study region.

1. Gitksan - Carrier Tribal Council Claim.
2. Kitimaat (Haisla Nation) Claim.
3. Nishga Comprehensive Claim.
4. Tahltan Comprehensive Claim.

A map outlining the boundaries of these claims can be found in a report titled "The Northwest Region" which was released on 15 September 1982 by D. Phillips, Minister of Industry and Small Business Development. Taken together these claims cover the entire study region.

The social and economic issues in the northwest region, as presented to the Cabinet Committee on Economic Development in 1981, are as follows:

(i) Economic Issues

- Need for economic diversity
- Differing financial capabilities among communities
- Competition among communities for tax base
- Lack of hydroelectric power in northern communities
- Lack of municipal infrastructure in north
- Improvements required on Highway 37
- CN/Highway 16 grade separation

(ii) Social Issues

- Capacity for growth in terms of land availability, suitability and service requirements.
- Low cost and rental housing sought.
- Urban fringe areas with limited financial capabilities.
- Northern community isolation.
- Limited television access.
- Rapid turnover of professionals.
- Indian land claims.
- Protection of the environment.

(b) Regional Communities

The following communities are contained within the regional area.

Terrace
Smithers
Telkwa
The Hazeltons (New Hazelton, South Hazelton and Hazelton)
Kitwanga
Gitksan Carrier communities
Nishga communities

Kitsumkalum Band
Kitselas Band
Rural Area in the Kitsumkalum and Nass valleys
Stewart

(i) Terrace

About 16 700 people are estimated to be living in the greater Terrace area (1980).

Terrace owes its existence primarily to the forest industries, as logging, sawmilling and cedar pole production are estimated to employ in excess of 1500 people under normal market conditions.

While forest sector employment has levelled out, the employment base of Terrace has diversified by expanding in other sectors over the past decade. Terrace acts as a regional service and administrative centre to an estimated 38,200 people, serving the Kitimat, Nass, Kitwanga and Hazelton areas as well as the immediate community.

The Terrace Community Plan generously allows for a population growth rate of 3.7 percent per annum from 1976 to 1996, a continuation of the growth rate that prevailed over the preceding 15-year period. Continuing expansion of the light industrial transportation and service sectors is expected to provide growth in future employment.

(ii) Smithers

Smithers is a town of almost 5000 people, located almost the same distance as Terrace from the project area. It differs from other communities in the study region in that it has a more diversified economic base. While forestry is still the major industry, agriculture, transportation, mining, tourism, and government administration provide a more balanced employment base so that the town is not so vulnerable to a downturn in any one sector. There is a substantial rural farm population around Smithers, supported primarily by beef cattle and dairy operations.

It is expected that Smithers will continue to grow at a moderate rate in a number of sectors. Increased rail traffic associated with the shipment of coal and grain through Prince Rupert and further expansion of trade, service and administrative activity arising from Smithers' central location in the region are seen as the primary sectors supporting future employment growth.

Community cohesiveness has traditionally come first in Smithers, and the community has attempted to achieve local control and management of its economic activity.

Smithers area residents have been careful about which industries have been encouraged to develop and how. Community organizations of all kinds are very active, and none more so than those organized in response to a potential impact from outside.

Social and protective services in the community are more than adequate to meet the present demand. In general, the quality of life for people living in and around Smithers is high.

(iii) Telkwa

The village of Telkwa has a population of under 1000. Logging is the major employment activity for residents. Telkwa does not maintain a strong service sector but instead utilizes services and facilities available in Smithers and/or Houston (Currie, Coopers and Lybrand Ltd., 1982a, b).

(iv) The Hazeltons

The three Hazeltons (Old Hazelton, New Hazelton and South Hazelton) form a triangle of small communities centred on the Skeena River, the railroad and Highway 16. These centres are 3 miles apart, thus creating transportation difficulties which deter co-ordinated community activity on a large-scale basis. Instead, each small community has its own unique community spirit depending mainly on the average length of residence (Moore et al., 1975). The population of the area around Hazelton is roughly half Native Indian (Blishen et al., 1979).

Local industries are relatively diverse and in various stages of development. The logging industry has in the past been the major employer of Hazelton residents. The major union in the community is the International Woodworkers of America. Economically the Hazelton area is depressed.

Another long-term industry in the area is agriculture in the Kispiox Valley and the Skeena Valley.

The Hazelton area benefits from tourist traffic travelling along Highway 16 to and from the Highway 37 junction at Kitwanga.

A relatively recent development has been the promotion of the "Ksan Village" where Native Indian Art and Handicrafts are exhibited. Started as a part-time venture, the "Ksan Village" project has grown and is now a major tourist attraction in the northwest.

(v) Kitwanga

Kitwanga is a small, unincorporated community of about 700 persons, located at the junction of Highways 37 and 16, about 92 km east of Terrace. B.C. Timber's sawmill is the largest single source of jobs in the community. A substantial number of Kitwanga's residents work in the logging industry, while retail trade and service industries provide employment for a much smaller number of people. The community is somewhat underdeveloped in service sector employment since it relies heavily on Terrace for many of these functions.

The Kitwanga Community Association is working with the Kitimat-Stikine Regional District to draft a town plan. This action was the result of community members' concern that impending development as a result of the new highway could result in strip commercial development, unless there were land use controls.

It appears that the Indian and white communities view themselves separately and there is little communication between them concerning long-term community planning.

(vi) Gitksan Carrier Communities

The Gitksan Carrier Tribal Council has its offices in Hazelton. The following Native Indian communities are located in the surrounding region.

Gitwangak
Moricetown
Kispiox
Gitamax

Kitwancool
Kitseguecla
Glenvowell
Hagwilget

The Council's prime concern in relation to any industrial development is the issue of land entitlement. Some of the Bands operate firms which contract clearing services. Food fishing, hunting and trapping are important.

A. Kitwancool

The Kitwancool Band is located on the Kitwanga River near Highway 37. In 1978, the total population of the Band was 293. There is a trend towards living off reserve. At least a third of the Band's work force is involved in the commercial fishing industry with the remainder employed in the logging and construction industries. The unemployment rate varies from 20 to 75 percent according to seasonal fluctuations in the fishing and logging industries. The most serious problems the community faces are a severe housing shortage and high unemployment.

B. Kitseguecla

Kitseguecla Band is located along the Skeena River east of Kitwanga. Highway 16 passes through the village. In 1978, the total population of the Band was 458. It is estimated that the work force numbers about 150 people. The unemployment rate, as with other area bands, is extremely high. Band members are employed mainly in the logging and fishing industries. The Band operates a logging truck operation and truck repair shop. Community services are also supplied by the Band to its members. Other necessary services are available in Hazelton, Smithers or Terrace.

C. Gitwangak

The village of Gitwangak located at the junction of Highway 16 and 37 is approximately 15 km from the Kispiox-Telkwa corridor.

In 1976, the population of Kitwanga Valley was 425 and the population of the Gitwangak Band living on reserve was 253. There has been an increase in the number of band members living on reserve. The Kitwanga area economic base is primarily logging and sawmill operations. The Kitwanga Lumber Company has a payroll of approximately 65, including subcontractors, and the Council sawmill employs about 250. The only other commercial operations include a store, cafe, garage and a few small retail outlets. There is some farming and ranching and several commercial fishermen. The Gitwangak Band is establishing a logging operation and is seeking funding to build a retail mall and another Band member has plans to build a motel. A gas station and restaurant presently operate on reserve.

(vii) Nishga Communities

The Nishga communities include New Aiyansh, Canyon City, Greenville, Gitlakdamix and Kincolith. Population numbers about 3200.

The Nishga Tribal Council's approach to development flows from their land claims declaration which include boundaries formally identified to government officials over 100 years ago.

The Nishga Tribal Council's policy is to promote opportunities for the people so that they will remain in their villages instead of leaving the valley to seek employment and/or housing. It is evident that over the next 10 years there will be additional pressures on the community to supply jobs for a work force that will effectively double in size. Expansion will also be required in community infrastructure and social services to meet the requirements of the increasing population.

The Bands presently provide members with basic social services, recreation and medical services.

Education is provided by the Nishga School District which began operation in 1977 and is Indian controlled. Bilingual education (Nishga and English) is offered in elementary schools at Aiyansh, Greenville and Kincolith.

Band members are employed primarily in logging operations, Band development projects and the commercial fishery. The Nishgas have a high degree of social vitality and political efficacy.

(viii) Kitsumkalum Band

The village is located approximately 4 miles west of Terrace on Highway 16, at the mouth of the Kitsumkalum River. The Kitsumkalum Band population is 134, (1983) approximately one half of whom live off reserve. The Band's main reserve is IR No. 1 near Terrace. There are 21 houses on this reserve. The size of the labour force is 24. The majority of the work force is dependent on the logging industry. Land is unused on Reserve Nos. 2 and 3, other than a gravel pit which is being leased by CNR. Reserve No. 1 is proposed for a light industrial park in anticipation of future demand from the Terrace area. The Band is concerned with the amount of development proposed for the northwest and sees a need for Indian involvement in planning. They are particularly interested in the heritage and socio-economic studies for the Stikine-Iskut transmission lines.

(ix) Kitselas Band

The Kitselas Band is located in the Terrace area. The population is 99 (1979) including on and off reserve members.

(x) Rural Area in Kitsumkalum and Nass Valley

Along the logging road going north from Terrace, there are a number of small homesteads. Similarly, a few rural houses are located in the Nass Valley near Aiyansh.

(xi) Stewart

Stewart is a mining community located at the head of Portland Canal.

Stewart would be the logical port through which to export mineral concentrates from a number of promising developments in the Stikine-Iskut area although such activity would not be particularly job-intensive.

The region around Stewart offers many potential tourist attractions, including glaciers, sportfishing, hunting and hiking opportunities, that would be a source of additional employment in the service sector, if only on a seasonal basis.

(c) Local Communities

(i) General

The generation projects area is sparsely populated, with several small communities and some isolated residences. The major communities in the local area are Dease Lake, Telegraph Creek and Iskut. As well, a small settlement, Bob Quinn Lake, at the southern end, is made up of employees and families of a highway maintenance centre.

There has been settlement in the area for over 10 000 years. Interaction with Europeans occurred in the early 1700s and settlement proceeded with the construction of a fort at Fort Simpson at the mouth of the Nass River in 1831. Another, at Dease Lake, was constructed in 1839. The area has been influenced by the fur trade, gold exploration, and lesser construction oriented projects. In the late 1950's, a major asbestos mining development was undertaken at Cassiar. In fact, in the Stikine-Iskut project area, Cassiar is the largest settlement with over 1000 residents. For the most part, however, continued and prolonged interaction and linkage with the developed areas of the province began in 1972 with the completion of Highway 37, from the Alaska Highway through to Stewart and to Highway 16 in the mid-west of the province.

There is a significant linkage between the three communities of Dease Lake, Telegraph Creek and Iskut, mainly through the Association of United Tahltans which represents the Tahltan Indians residing in each location. As well, Dease Lake serves as a terminus for the other two and provides some central services, although the major service centres are Cassiar and Whitehorse to the north, and Terrace and Smithers to the south.

(ii) Dease Lake

Originally settled as a trading post in 1839, Dease Lake had only three resident families in 1972, just prior to the completion of Highway 37. By 1981, the population had grown to over 130 families totalling approximately 400 residents. A majority of this total are native, mainly of Tahltan descent.

Dease Lake is located in the unincorporated Region of Stikine. There is no local municipal government, although there is an Advisory Planning Committee which deals with concerns such as zoning in conjunction with provincial agencies.

Dease Lake has had relatively rapid growth in the past decade and this could continue if it becomes a sub-regional centre as suggested in the North-West Report.

Major Employers

1. highway maintenance;
2. Ministry of Forestry;
3. water bomber base.

Other Income Sources

1. service stations;
2. motels;
3. restaurants;
4. government services (police, post office);

5. trapping;
6. income substitutes (hunting, fishing).

Housing

1. adequate supply - no surplus;
2. wells and septic sewage.

Services

1. school - grades 1 to 9;
2. health - nursing station (visiting doctor and dentist);
3. police - two RCMP;
4. fire;

5. social services - based in other communities.

Other services and facilities are unknown.

(iii) Iskut (including Eddontenajon and Tattogga)

Iskut is a relatively recent settlement, having been selected as an Indian reserve site in 1974. Located adjacent to Highway 37, south of Dease Lake, the village is easily accessible. Iskut is, in effect, three communities - native reserve, non-native settlement, and residents along Highway 37. Although there is a great deal of commonality between the non-native residents, these communities do not necessarily act in concert, nor, in fact do they always share common services.

At the present time, the aggregate population is about 300 persons. Approximately 70 percent of this total are natives living on the reserve.

There is a Band Council which is responsible for the administration of the reserve, but there is no formal administration for the non-native residents. The area is part of the Kitimat-Stikine Regional District and local planning is accomplished in conjunction the Regional District and with the Advisory Planning Committee made up of local residents (native and non-native).

Major Employers

Native

1. band-related jobs (administration, band store, post office);
2. reserve school;
3. reserve construction;
4. seasonal wage - labour;
5. river rafting.

Non-native

1. highway camp;
2. school.

Other Employment

1. tourism;
2. highway services;
3. mineral exploration.

Other Income Sources

1. welfare;
2. hunting, fishing, trapping, guiding.

Housing

1. on reserve (no adequate surplus);
2. off reserve (many mobile homes - no surplus);
3. wells and septic facilities.

Services

1. school - (grades kindergarten to 9) adequate for present needs;
2. health - nursing station (visiting doctor and dentist);
3. social services - located in other communities.

(iv) Telegraph Creek (Glenora, Tahltan)

Telegraph Creek, like Dease Lake, was established in the early 1800s during the fur trade era. Occupation, however, has been more consistent than at Dease Lake. Telegraph Creek is located 70 miles southwest of Dease Lake. Access is difficult by means of a narrow dirt road. In 1981, reported population was approximately 300, three-quarters of which were native (Tahltan). The non-native residents reside in the old town (below the reserve) or in Glenora, a few miles downriver. As with Iskut, the native and non-native communities are quite different.

The reserve is administered by a Band Council, while there is no formal local administration for the non-native segment. Administration for the area is conducted through the Kitimat-Stikine Regional District and an Advisory Planning Committee has been established.

For the most part, the non-native population has migrated to the area to pursue an "alternative lifestyle" based on a wilderness experience. Unlike the other communities, growth has not resulted from wage employment, service opportunities or speculation.

Major Employers

Native

1. band-related (administration, band store, post office, fire department, medical clinic);

2. reserve construction;

3. Tahltan Association.

Non-native

Little consistent employment.

Other Employment/Income Sources

1. mining (Cassiar);
2. school;
3. guiding/tourism;
4. hunting, fishing, trapping;
5. homesteading.

Services

1. school (grades kindergarten to 10, relatively new;

2. health - reserve clinic (visiting doctor and dentist);

3. social services - located in other communities;

4. other services/facilities - unknown.

This area is significantly different from the other local communities. Being relatively difficult to access, there is far less interaction with industrial activity and wage employment. This area has been less affected by growth accompanying resource exploration and exploitation. For the most part, wage income appears to be a supplement to subsistence activity (hunting, fishing, trapping) rather than a permanent major income source. This is equally valid for the native and non-native residents. For migrants the attraction of the Telegraph Creek area seems to have been the lifestyle rather than economic opportunity.

5.3.3 Impacts

(a) The Region Without the Projects

Socio-economic impacts in the region are discussed by comparing future scenarios with and without the hydroelectric development. In the discussion of the without-the-project scenario, the following four futures were assumed.

1. - no major mining developments
   - no major recreation developments
   - study area annual population growth of 2.6 percent

2. - no major recreation developments
   - a major mining development opening between 1980 and 2010
   - increase in study area population by 1050

3. - some addition of recreation facilities
   - no mining developments
   - study area annual population growth of 2.6 percent

4. - addition of recreation facilities
   - a major mining development opening between 1980 and 2010
   - population increase in study area of 1050

(b) Project Characteristics

The major source of socio-economic impacts due to the proposed development will be the short-term imposition of a large number of construction workers and in some cases families in the area. Manpower and likely accommodation requirements are given in Tables 5-21 and 5-22.

Accommodations would be provided on a temporary basis (6 to 9 years) as indicated in the table below. For transmission, the number of people seeking accommodation at each location would vary with the segment and stage of construction. Each transmission location could accommodate up to 200 people. Accommodation may be provided either by camp or in local motels and hotels, at the discretion of the contractor.

CONSTRUCTION CAMP LOCATIONS

Location	Work Force	Status
Stikine Canyon	generation & transmission	single/family
Tanzilla	generation & transmission	single/family
Iskut Canyon	generation	single/family
Bob Quinn	generation & transmission	single/family
More Creek	generation	single
Natadesleen Lake	transmission	single
Burrage Creek	transmission	single
Bell 2	transmission	single
Meziadin Lake	transmission	single
Van Dyke Airstrip	transmission	single
Upper Kitwanga	transmission	single
Smithers	transmission	single
Hazelton	transmission	single

During operations B.C. Hydro is suggesting the primary permanent family community be located on Highway 37 at Bob Quinn lake with some permanent family accommodation at Stikine Canyon (see Report on Stage I Settlement Studies, B.C. Hydro 1984c).

(c) Impact of Project on Region

(i) Material and Equipment Requirements

Preliminary estimates indicate that the project would require, in total, about 1.5 Mt of materials and equipment. Cement (800 000 t) and flyash (300 000 t) account for more than 75 percent of the total quantity of material to be transported.

It is considered likely that most of the cement would be shipped from Lower Mainland plants by barge to Stewart and thence to the project sites by truck, while the flyash would be supplied by rail and/or road from an inland source. Other permanent materials and job supplies would be shipped primarily by road; rail transportation, where available, would probably be limited to larger items for which there are significant advantages in reducing the distance travelled by road. There will also be a need for transhipment of rail freight possibly at Kitwanga or Smithers.

(ii) Impacts on Regional Highways

Up to 80 trucks per day would travel northwards into the Stikine-Iskut area during the summer months of the 3 or 4 peak construction years; 40 of these would carry cement. This represents a fourfold increase in daily truck traffic, compared to the present level of 25 trucks. An additional increase in passenger vehicle traffic can also be expected to occur in conjunction with the project.

Some concern has been expressed that such an increase in traffic would not be safely accommodated on Highway 37 at present, without substantial improvements to widen the road and bridges and generally upgrade the highway. However, the Department of Highways has an ongoing program to upgrade Highway 37.

If the upgrading of Highway 37 and other infrastructures is advanced due to the project, some benefits could accrue to other sectors e.g.:

1. The reduction of personal transportation costs, in terms of both time and money.

2. Lowered costs of transporting freight to regional residents.

3. Reduced costs of exporting mineral and forest products through the Port of Stewart.

(iii) Impact on Railways

As noted earlier, railway movement of project inputs to the region would likely be restricted to flyash and a limited quantity of larger items. Peak flyash requirements would be 92 000 t/a. This would be moved by the CNR as far as Kitwanga, or perhaps Smithers, and transhipped to the project area by truck. The impact on the CN rail system would be negligible considering that 15 to 20 million tonnes are projected along the route without the project by the 1990s.

(iv) Impacts on Ports

Stewart is expected to experience the largest increase in port activity during construction of the project. The total tonnage moved through Stewart would probably exceed 1 Mt, including the movement of fuel, construction equipment, turbines and generating equipment from offshore sources and general supplies in addition to 800,000 t of cement. During construction up to 45 trucks per day would be required to haul cement from Stewart to the project sites. This amount would be concentrated during the months from April until October, at which time it would cease for winter.

Allowing for the movement of other materials through Stewart, particularly diesel fuel, it is estimated that about 50 trucks per day would leave Stewart for the Stikine-Iskut region during the summer months of the peak construction year.

In order to accommodate the projected increase in commodity movement through Stewart, it is anticipated that a number of additions to existing port facilities would be required.

1. A bulk unloading facility and associated storage sites to handle cement shipments.

2. One or two additional tide ramps to handle roll-on/roll-off movements of construction equipment and general commodities.

3. A bulk fuel unloading facility and associated storage for diesel fuel and gasoline shipments moving north to the project site, although the existing Shell facility may have the capacity to handle fuel requirements of the project.

These facilities could be accommodated by additions to the existing causeway from which Arrow Transport ships asbestos from Cassiar. Such an increase in port activity and truck traffic would require additional truck drivers, mechanics, longshoremen, and office and supervisory staff. With a traffic increase of 50 truck loads per day from Stewart, the direct increase in transport-related employment would probably approach 125 to 150 people, assuming that all of the additional staff were based at the Stewart end of the run (Arrow Transportation, personal communication).

(v) Impacts on Air Transport

Plans for air transport have not been finalized and will require further consultation with government agencies. Possibilities include use of existing strips at Dease Lake, Iskut Village (if upgraded) and upgrading of the abandoned strip at Morchuea Lake. In addition a new airstrip could be constructed near Stikine Canyon. Trans-Provincial Airlines, which presently serves the region, would need to increase the size of its aircraft and possibly the frequency of service in order to accommodate the movement of construction workers to and from the project.

The impact on airport facilities in Terrace and Smithers resulting from increased air traffic from project workers would be noticeable but manageable, given the fact that these airports are not heavily utilized at present.

(vi) Other Impacts

Regional residents would be affected by the project in a number of ways described below:

1. Residences Affected - There is one property (with a house) crossed by the transmission route in the Skeena Crossing area (see the Land Use report, Eikos (1983), for details). This particular crossing has been studied in greater detail than the remainder of the route and it has been determined that the right-of-way can be kept clear of the property buildings. In addition, one farm in the Telkwa Substation area (km 369) would require relocation. This latter area should be investigated further if the project is reactivated.

2. The native Indians in the region would experience changes due to the project which will alter land uses in areas over which they consider they should exercise control. In addition, reductions in fish and wildlife resources would affect their subsistence economy.

3. The regional residents perception of their lifestyle would be altered. Many would view the Stikine Development as the first step in opening future developments based on resource exploitation. Some people would view the transmission lines and dams as decreasing the wilderness nature of the region. Others may see the development as a needed opportunity for expansion in the area.

4. Both Highway 16 and 37 would experience an increase in traffic. Safety, noise and dust may be a concern to those who live alongside these roads. In the smaller communities where transmission construction workers may obtain accommodation, some social problems may occur with their use of restaurants and pubs. Some communities may decide to develop services to meet the needs of transients, e.g. entertainment and restaurants rather than needs of long-term residents.

5. Employment opportunities may exist for regional residents, particularly with the clearing of transmission line. Equipment operators, labourers and fallers would be required and it is likely that people with these skills live in the region. Other employment opportunities may occur related to transportation, particularly at transhipment points such as Kitwanga, Smithers and Stewart.

6. Business opportunities may be enhanced for those people whose businesses cater to construction workers needs. This would occur in the larger communities such as Terrace where workers may fly to recreate or travel south and the smaller communities which may accommodate transmission construction workers.

(d) Impacts on Regional Communities

(i) Terrace

As a retail service centre for the region, Terrace merchants could be positively affected by increased economic activity from construction workers.

(ii) Smithers

The direct impact would occur from the Stikine development relating to the movement of materials on Highway 16 and the possible increase in economic activity from the transmission construction workers and generation construction workers in transit or on recreation leave.

Smithers provides services to the surrounding rural areas and is concerned that increased access will affect negatively the livelihood of the registered guides and trappers and other people who depend on subsistence activities.

(iii) Telkwa

The Smithers/Telkwa area has been identified as locations for construction personnel working on the southern end of the transmission line. It is expected that up to 200 workers would use existing hotel/motel accommodation or be housed in a construction camp, at the contractors discretion. This would provide a short term economic benefit to business people. Some social adjustments might be expected while workers use local restaurants and pubs.

(iv) Kitwanga

Similar to other small highway communities, Kitwanga would be affected by increases in traffic. Safety, noise and dust would be a concern.

As a transhipment point some spinoff economic development might occur. The facilities may require upgrading. Economic benefits could occur to business if local spending by construction and maintenance crews were encouraged.

(v) The Hazeltons

Both New Hazelton and South Hazelton would be affected by highway related impacts described earlier.

New Hazelton representatives were particularly concerned with the possible effects of transmission line route clearing on the local timber market. If "outside" contractors came in, the local people would be in a position of competing in the same market for sales. There is also the danger of glutting the market and forcing shut downs or layoffs at local operations.

In terms of social problems, all the settlements around the Hazeltons are very small and there may be some short term adjustments as a result of the up to 200 construction workers who may be using existing hotel/motel accommodation. In-migrating employees would be resented because of the high unemployment among the local people.

(vi) Gitksan Carrier Communities

The Gitskan Carrier Tribal Council has expressed concerns about the Stikine-Iskut Development. They will not participate in any planning process until the provincial government changes its position on their claims for land settlements.

The most controversial part of the transmission line route is in the Skeena Crossing area. Although the route does not traverse Reserve land it passes near two communities, Kitwancool and Kitseguecla. This area is part of the Gitksan Carrier land claims area. Construction of the transmission line would be seen as intrusive.

Extensive food fishing is carried on throughout this area. There will undoubtedly be extreme concern among the people as to possible loss or damage to fishing sites. B.C. Hydro would follow normal construction and monitoring procedures to avoid such impacts.

Traffic related impacts described earlier would apply to the Gitksan communities located on the highway.

(vii) Nishga Communities

Increased road traffic may result in increased noise and safety hazards for those living in the New Aiyansh area.

The Nishga Tribal Council has formally opposed the Stikine-Iskut development and has called for a moratorium until the Province has given appropriate attention to the settlement of native land claims.

(e) Impacts on Local Communities

(i) Without the Stikine-Iskut Development

The area will likely grow at a relatively slow rate in the absence of alternative major development or some other stimulus such as completion of the railroad. Dease Lake will continue to expand as a sub-regional centre, while Iskut will expand as service requirements warrant. These communities will expand at a faster rate than Telegraph Creek, due to their location on Highway 37. The on-reserve native population will increase slowly, since it is assumed there will be no in-migration from other areas of the province.

From an economic perspective, the number and types of activities will remain relatively the same as at present. As there are no firm indications of major resource industry investments over the next decade, this report assumes there would be no substantial increase in wage-income opportunities and corresponding population increases.

(ii) With the Stikine-Iskut Development

There are three types of local community impacts associated with the Stikine-Iskut development: lifestyle and cultural, facilities, and residential.

1. Lifestyle - Any large influx of workers into a sparsely populated area can be expected to cause substantial social and economic dislocations (Canadian Resourcecon, 1982). In fact, the major impact of the Stikine development would likely be with respect to lifestyle and culture of local residents, especially for the native population. Although there has been non-native contact

for over one hundred years during the fur trade and gold rush periods, the area became relatively easily accessible only in 1972, following the completion of Highway 37. Recent studies in other areas indicate that large scale development has proven to have far more adverse effects on native peoples than those associated with either the fur trade or the gold rush (Canadian Resourcecon, 1982). The impacts are related to the rapid increase in non-native population, the relative permanence of the development, difference in value systems and alienation of land. The Stikine-Iskut development project area must be considered as being especially vulnerable to causing adverse lifestyle change. Mitigation programs will need to identify ways to speed the process of adapting to the new development.

The Tahltans position is that studies on the Stikine should be curtailed until claims have been settled.

2. Facilities - The project will result in a major increase in the population of the area, both from direct project employment and secondary or induced employment. It has been estimated that area population will increase from 1000 pre-project to over 7000 at the peak of construction. This increased population will have some general area impacts as well as impacts specific to the various communities, such as:

   a. increased traffic;

   b. increased pressure on accessible recreational resources (including hunting and fishing).

At least 95 percent of the direct personnel are predicted to reside in the construction residential facilities at or near the project sites. As a result, the population increase in the existing communities will be significantly smaller than work force estimates indicate.

Dease Lake

Population

Resourcecon projected that the local population would increase from 300 residents to over 1000 residents at the peak of construction. Most of this increase will be the result of induced employment assuming that Dease Lake becomes the primary local service centre for the two Stikine projects. This rapid growth is expected to put severe strain on the facilities of the community.

Economic

- Jobs - Some 30 to 40 residents would obtain secondary employment. Some local residents would also find jobs working on project construction but the number is not possible to estimate at this stage because skill levels and attitudes towards employment are not known.

  As early as the first year of construction the number of labouring and clearical jobs would exceed the expected number of local people available. However, as with all construction jobs the mix of local employees and regular construction industry employees will depend partly on any union agreements.

- Income - Per capita income will increase on average, but disparity will widen between full-time employed residents and part-time and/or subsistence residents.

Housing

- major housing shortages could occur;
- temporary facilities (mobile homes) would be required;
- land speculation could lead to price increases;
- strain on already problematic water supply and sewage disposal systems.

Services

- Education - School facilities are inadequate for the expected level of increased population.
- Health - Expanded and improved facilities would be required.
- Justice
  - Police - adequate facility; additional personnel required.
  - Other services will continue to be provided from outside the area but a greater need for these services may develop.

- Fire - An expanded facility would be required to upgrade this service.

- Commercial - Most commercial facilities are located in other areas. A larger population base may attract some commercial development.

- Cultural/Recreational - Unknown at present.

Other Concerns

Problems may result between in-migrants and longer term residents with respect to decisions regarding community function and facilities. If Bob Quinn is established as a settlement, this could reduce the expansion of Dease Lake.

Iskut Village Area

Population

- Native - There is no projected change resulting from the project.

- Non-native - This population is projected to double (100 to 200 persons) as a result of the community's proximity to Highway 37 and the project access road.

Economic

- Jobs - It is estimated that ten service sector jobs would be created. Some construction work may also be available. Additional employment might be created if the airstrip is used to meet project needs.

- Income - Non-native income would increase resulting in greater income disparity between the native and non-native component of the area. Fish resources are expected to decline due to increase angling pressure in Morchuea, Kluachon and Eddontenajon lakes. Reductions in wildlife populations are also expected. These losses would result a diminished capability to exist on hunting and trapping.

Housing

- A housing shortage is forecast.

- Mobile homes would likely be required. Off-reserve accommodations would probably be utilized.

- New water and waste disposal facilities would be required.

Services

- Education - The existing reserve school is large enough for the native population. New facilities would be required for projected in-migrant population.

- Health - Existing facilities would need to be upgraded.

- Justice

  - Increased RCMP personnel would be required to service this area. (RCMP are located in Dease Lake.)

  - Other judicial and legal services from outside area would have to be increased.

- Fire - Existing services would require upgrading.

- Social Services - Additional services from outside the project area would be required.

- Commercial - Some increase in service facilities along Highway 37 is projected. Iskut may compete with Dease Lake for provision of commercial services to project employees residing in the project settlements.

- Cultural/Recreational - Unknown.

Other Concerns

As with Dease Lake, the additional population will be non-native in-migrants. Since there is no formal integration between the reserve community and the non-reserve community, the increased population may result in significant strain between the various resident groups, especially if it appears that the economic benefits associated with the project are being realized disproportionately by the non-native residents.

Telegraph Creek Area

Population

No permanent project-related growth is expected; however, an increase in transient (visitor) population can be projected.

Economic

No major change in employment opportunities is expected in this community, although some residents may be hired for project work. In addition, some benefits could accrue from an increased tourist trade. Relative incomes are not expected to change significantly. Non-wage income (subsistence) may be affected due to losses of wildlife and fish resources.

Other Areas

No significant change in facility requirements are projected as a result of induced population resulting from the project.

3. Residences - Two people residential properties would be directly affected by the project. One lies within the proposed Stikine Canyon reservoir and relocation would be required. The other has property on the transmission line above the Todagin Creek crossing. The proposed route runs very close to the existing residences and

relocation, possibly to another location on the lot, might be necessary.

A third person, a squatter, lives close to the proposed transmission route in the Forty Mile Flats area.

(iii) Other Communities

There are several communities north of the project which would be affected to some extent by the proposed development. These are Good Hope Lake and Cassiar on Highway 37 and Watson Lake, Yukon, on the Alaska Highway. Good Hope Lake is a native community located between Dease Lake and Cassiar. Impacts to this community are expected to be minor since there would be little project-related traffic and no construction activity in the approximate area. There may, however, be some increased employment opportunity. In Cassiar, there is a large pool of skilled labour which may be attracted to the project if there is a significant difference in wage rates. However, given the short term nature of the project's construction, employment and the different skills required, it is unlikely that the number of transfers would be large. As well, Cassiar now serves as a commercial centre for residents of Dease Lake, Iskut and Telegraph Creek. These services would be strained if there was significant population growth resulting from the project.

Watson Lake is the closest community to the project which offers scheduled airline service to the major centres of the province. Being larger (about 1500 people) than others in the region, it also may attract project workers during their time off. This could provide some economic benefit to the businesses in the community.

5.3.4 Conclusions

The socio-economic implications of the Stikine-Iskut development are complex. Broadly speaking, impacts would be felt on two components namely physical facilities and lifestyles. Regarding the first, construction of major generation and transmission projects in this isolated area over a short period could strain community and regional facilities and services. However, experience elsewhere shows that additional facilities and services can normally be provided with careful planning including the involvement of government and residents.

Regarding the second, the project would be beneficial for those people who are part of the wage economy and who perceive that hydroelectric development signifies progress. For those people who depend on the subsistence economy or who place high value on the wilderness, the project would require significant adjustments. The increased population and corresponding increase in competition for land and resources (e.g. fish, wildlife, and agricultural land) would cause conflicts with the present lifestyles. Moreover, the issue of land claims and its relationship to development remains critical. This issue has implications, not only because of its priority for local and regional native people, but also because of the political and legal complexities it presents.

If hydroelectric and other development is to occur in this area, the residents must be involved in identifying what can be done to facilitate these adjustments. B.C. Hydro can assist in providing technical and financial assistance to ensure effective adaptation to changes from project development.

Although the socio-economic impacts of the Stikine-Iskut development are potentially large, especially with respect to impacts on subsistence-based lifestyles, it is unlikely that the problems would be sufficient to affect the project's feasibility. Nonetheless, the question of land claims continues to be of over-riding concern and should be recognized when considering project feasibility.

5.4 SETTLEMENT STUDIES

5.4.1 Background of Studies

(a) Overview

The Stikine-Iskut generation projects would result in an influx of significant numbers of people into the project area for both temporary and long-term periods. "Settlement studies" have identified numbers of expected in-migrants and developed a plan for accommodating them. The studies are needed since the peak construction work force of about 4000 exceeds greatly the population of existing local communities (i.e., Telegraph Creek, Dease Lake and Iskut have populations less than 500 people each). Even the operating work force of only 80 would be of significant size compared with existing populations. Settlement studies have both engineering and environmental implications because planning for settlement facilities for the projects is involved, and these facilities would be part of the socio-economic development of the region.

Aside from preparing a plan for orderly settlement associated with this development, the eventual objective of these studies is to prepare a Conceptual Settlement Plan for Energy Project Certificate Application. After project approval, detailed settlement design and implementation would follow.

(b) Studies to Date

With settlement advice from R.A. Rabnett & Associates and advice on socio-economic matters from Canadian Resourcecon, settlement practices and experiences of B.C. Hydro's past developments were reviewed and a Stage 1 report prepared (B.C. Hydro, 1984c). Other major developments in Canada were also reviewed. Project designs and biophysical restraints on possible settlement options were considered, leading to a preliminary identification of the option preferred by B.C. Hydro. Interests of others, such as local communities and Regional Distrct, were deduced primarily at arms-length and included as best as possible in the selection process.

The main task in the studies were the determination of the number and location of family accommodations for both the construction and operating periods. The number of employees on single status would be influenced by the availability of accommodations near a project or in existing communities and the acceptability of opportunities for daily or periodic commuting to local and urban centres. Essentially, the single status component of project employees is the remainder after identification of the married status component.

The study was extended to identify sites for single labour camps and family communities. The purpose of this was to provide preliminary data for the project design and to ensure that satisfactory sites were available for family communities. However, further studies will establish the acceptability of the preferred settlement options and the need for the selected sites.

5.4.2 Interim Conclusions

A major conclusion is that settlement patterns for the Stikine-Iskut development should be similar to previous hydroelectric projects in remote areas. For the project construction period, family accommodations should be provided for up to 20 percent of the work force (primarily staff and technical employees). Single labour camp accommodations should be provided for the remainder. A small part of the construction accommodations should be permanent and retained for use in the operating period. The preliminary selection identifies approximate locations and extent of accommodations as follows:

Project	Construction Period	Operating Period
Stikine Canyon	Family community, population peak 1300. Single labour camp, peak occupancy 2500.	Family accommodations retained from construction period for 50 people (30 average occupancy). Single accommodations for 40 retained from construction period for variable use. Also utilize More Creek accommodations on a periodic commuting basis.
Tanzilla	Family community, population peak 900. Single labour camp, peak occupancy 1600.	Use accommodations as for Stikine Canyon.
Iskut Canyon	Family community, population peak 900. Single labour camp, peak occupancy 1500.	Use accommodations as for More Creek.
More Creek	Family community near Bob Quinn Lake Highways camp, population peak 500. Single labour camp (at site), peak occupancy 600.	Family accommodations retained from construction period for 300 people including highway-related residents. (Single accommodation requirements met by highway-related facilities.)

Apart from the Bob Quinn Lake community, all accommodations provided by employees would be at least 40 km from any existing community. In addition, a number of employees (especially previous local residents) would probably choose to make their own arrangements primarily in existing communities.

Costs of the family communities have not been estimated in detail since the quantity and standard of the required facilities is not defined at this stage. However, based on past experience the added cost of the construction period family communities proposed would be about $40 million. This and costs of single labour camps are included in the construction facilities estimates for the projects. Annual costs during the project operating period would be in the order of $1 million (excluding amortization of construction costs). All of these costs are justified by improved efficiency from a better and more stable workforce.

5.5 RESOURCE EVALUATION

5.5.1 Summary of Studies

To evaluate the benefits and costs of changes in environmental and socio-economic resources and resource use as a result of the development, a resource evaluation study is required. McDaniels Research Ltd. conducted investigations in this subject area from 1980 to 1983 and have reported results in a draft resource evaluation report. While the report results are summarized in general terms below, the calculated values for resources were based on preliminary data and, due to their speculative nature, are not presented.

5.5.2 Methods

Biophysical and socio-economic information on anticipated effects of the development were evaluated on the basis of social benefit/cost principles. Whenever possible the development effects were evaluated in dollar terms to facilitate their comparison with the benefits provided by power production.

A three-stage calculation is employed to estimate the resource opportunity costs attributable to the Stikine-Iskut hydroelectric development. First, the net social benefits associated with maintaining current resource use patterns (that is, the "without-the-development" base case) are estimated for each resource. This without-the-development case is based on measures of current net benefits from a given resource and forecast changes in future resource uses and values. This process requires not only a careful inventory of present resource uses and their estimated value to current users but also a projection of future resource use options under alternative management schemes, demand estimates, and both socio-economic and biophysical constraints.

Once without-the-development values based on both existing and potential uses of the resource base have been analyzed, the net social benefits of the resource are calculated assuming development of the area for hydroelectric power. Alternative projections of future conditions will yield a measure of the sensitivity of the estimates to changes in key variables. Finally, the discounted resource values without and with the project are compared, with the differences providing an estimate of the net resource costs or benefits attributable to the project.

Three principal accounts are employed in this analysis. The objective of the income account is the maximization of net social provincial income. It corresponds to the traditional benefit/cost approach in which only effects, which can be quantified in dollar terms are included, and values are assessed on the basis of opportunity costs. In keeping with B.C. Hydro's benefit/cost framework, the referent group, or viewpoint of analysis, is comprised of all provincial residents.

One shortcoming of the income account is that it gives no weight to the effect of resource changes upon particular subgroups within the province. These questions are the concern of the equity account. Here the distribution of benefits and costs associated with resource changes to be caused by the Stikine-Iskut development are discussed.

Although a broad consensus has been reached for the analysis of the income effects of a project, as exemplified by the provincial guidelines (1977), the danger exists that project effects which cannot be expressed in commensurate dollar terms will either be omitted from the analysis or regarded as less important. The development effects which are likely to be environmentally significant and yet which cannot be adequately evaluated in dollar terms are therefore summarized in qualitative or biological units in an environmental account.

5.5.3 Results

Forestry, recreation, fisheries, wildlife and other resources and resource uses, such as agriculture, mineral development, transportation and water resources were evaluated under the income account. At a discount rate of 8 percent and assuming a 70-year life span, the preliminary assessment found that the development would result in social costs ranging in importance as follows: recreation> wildlife> fisheries>> transportation and agriculture. These costs were shown to be offset by a large apparent benefit to forestry, while no costs were predicted for mineral developments and water resources.

For the equity account, no new major uncompensated social costs were identified. For the most part, the equity issues relate to the loss of the wilderness character of the area which could result in:

1. crowding and reduction in quality at accessible recreation areas during the construction phase;

2. reductions in the size and quality of fish and game populations;

3. greater travelling distances needed to obtain fish and game;

4. loss of some lifestyles that involve hunting and fishing;

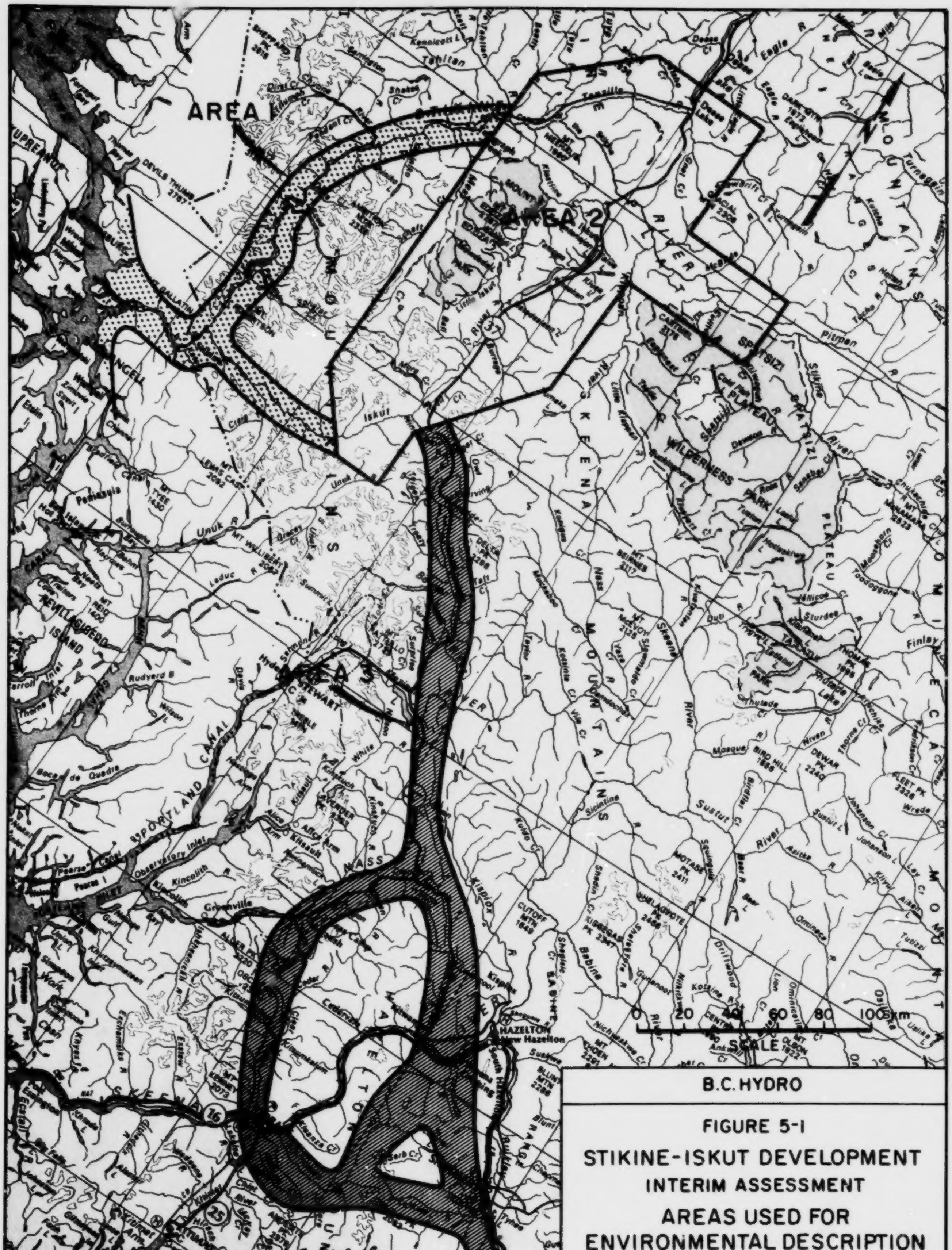
5. loss of some future options regarding recreation resources.

Preservation value, or the value to the province of maintaining a wilderness in the development area, was the only item identified in the environmental account. Although methods are currently being developed in the scientific community to evaluate this kind of resource, no dollar estimates are yet possible.

5.5.4 Conclusion

Resource evaluation studies for this development are at a preliminary stage and a detailed analysis will be required close to an energy projects application date. The detailed analysis will require an update of all biophysical and social studies which serve as input.

Based on the preliminary data, it appears that most major resource costs of the development are balanced by benefits. Disproportionate losses that will accrue to local residents on the equity account are related primarily to loss of the wilderness character of the area. An additional but non-quantifiable cost of the development is loss of the preservation values. Providing there is general acceptance of the trade-off of wilderness for power, there does not appear to be environmental and social costs which would be sufficient to preclude this development.


AREA 1
AREA 2
AREA 3
SPATSIZI PLATEAU WILDERNESS PARK
SKEENA MOUNTAINS
PORTLAND CANAL
STEWART
HAZELTON
New Hazelton
DEVILS THUMB 2767
0 20 40 60 80 100 km
SCALE

B.C. HYDRO

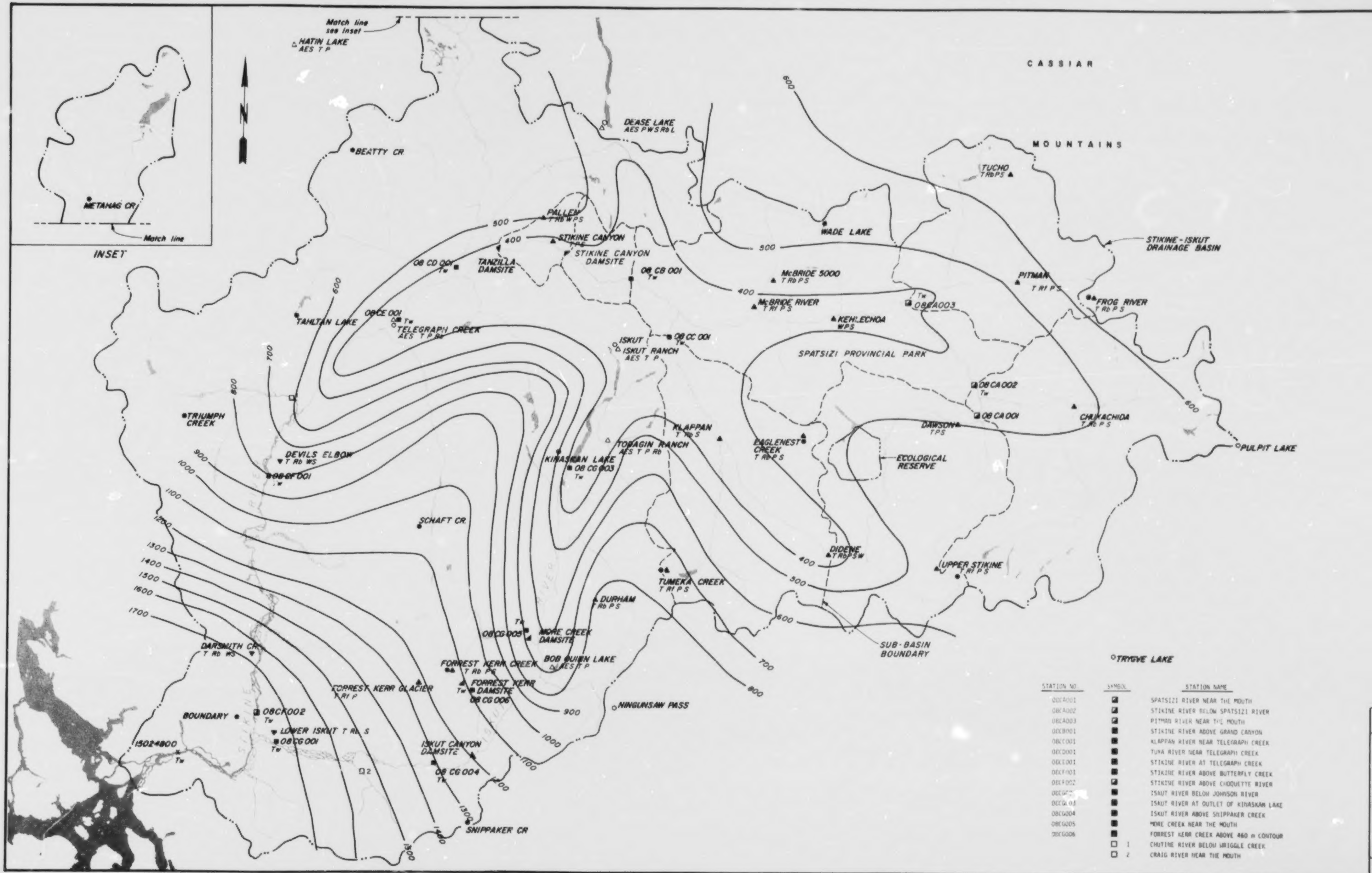
FIGURE 5-1

STIKINE-ISKUT DEVELOPMENT

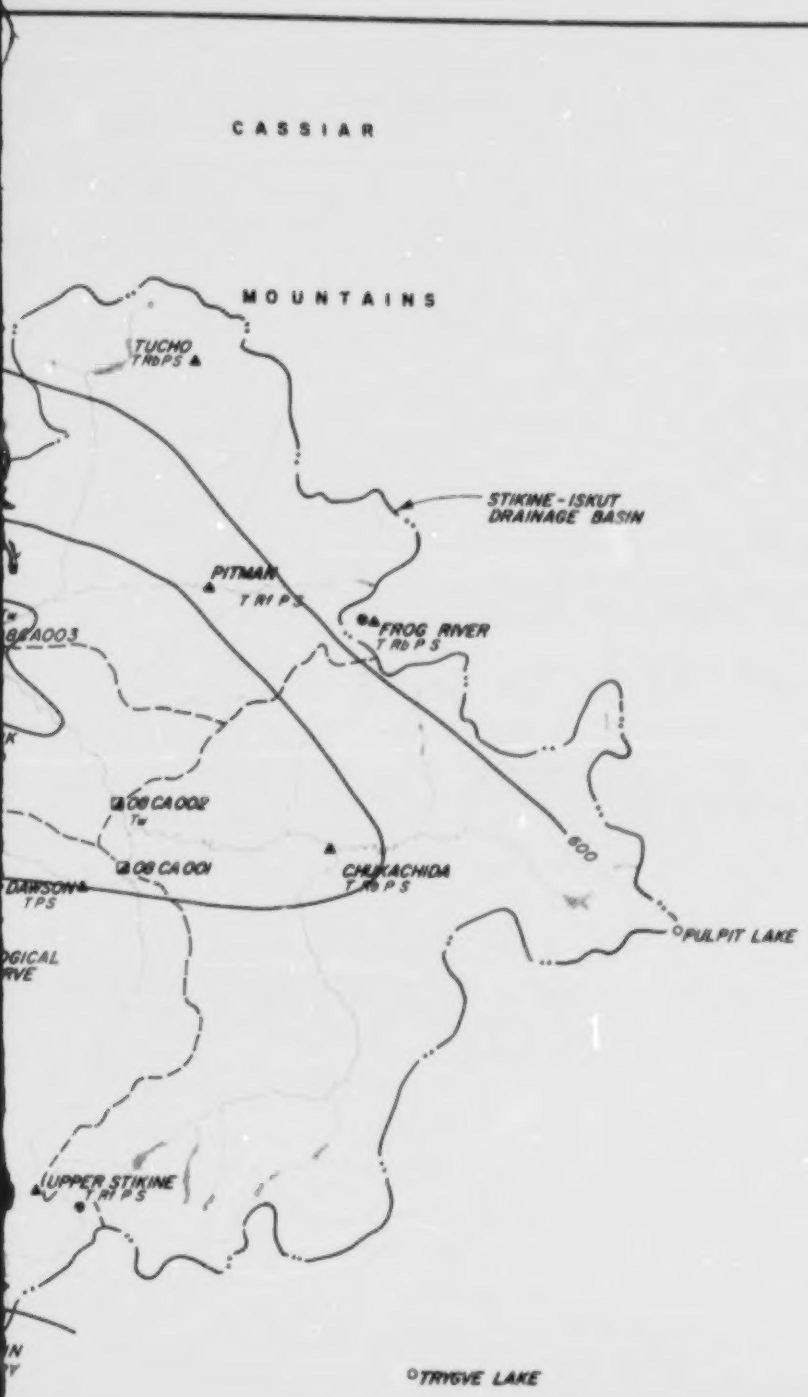
INTERIM ASSESSMENT

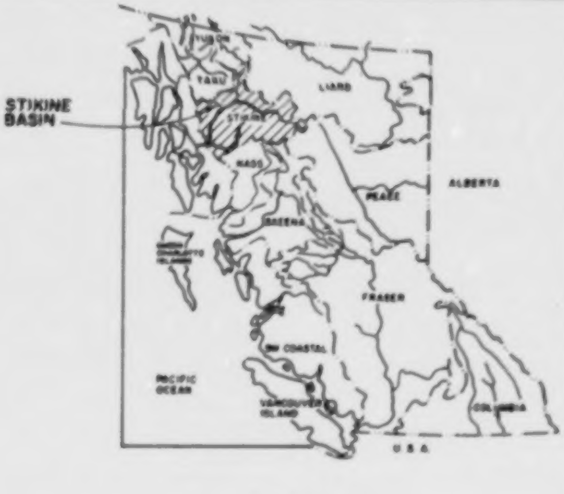
AREAS USED FOR ENVIRONMENTAL DESCRIPTION

NOVEMBER 1984


Match line see inset
HATIN LAKE AES T P
METAHAG CR
Match line
INSET
N
CASSIAR
MOUNTAINS
DEASE LAKE AES PWSRbL
BEATTY CR
PALLEN T Rb WPS
STIKINE CANYON TPS
STIKINE CANYON DAMSITE
TANZILLA DAMSITE
08 CD 001 Tw
08 CB 001 Tw
WADE LAKE
STIKINE - ISKUT DRAINAGE BASIN
McBRIDE 5000 T Rb P S
McBRIDE RIVER T Rl P S
PITMAN T Rl P S
FROG RIVER T Rb P S
08 CA 003 Tw
KEHLECHOA WPS
TUCHO T Rb P S
TAHLTAN LAKE
08 CE 001 Tw
TELEGRAPH CREEK AES T P Rb
ISKUT
ISKUT RANCH AES T P
08 CC 001 Tw
SPATSIZI PROVINCIAL PARK
08 CA 002 Tw
08 CA 001
CHUKACHIDA T Rb P S
DAWSON TPS
PULPIT LAKE
TRIUMPH CREEK
DEVILS ELBOW T Rb WS
08 CF 001 Tw
KLAPPAN T Rb S
TODAGIN RANCH AES T P Rb
KINASKAN LAKE
08 CG 003 Tw
EAGLENEST CREEK T Rb P S
ECOLOGICAL RESERVE
SCHAFT CR.
DIDENE T Rb P S W
UPPER STIKINE T Rl P S
TUMEKA CREEK T Rl P S
DURHAM T Rb P S
08 CG 005 Tw
MORE CREEK DAMSITE
BOB QUINN LAKE AES T P
SUB-BASIN BOUNDARY
TRYGVE LAKE
DARSMITH CR T Rb WS
FORREST KERR CREEK T Rb PS
FORREST KERR GLACIER T Rl P
FORREST KERR DAMSITE
08 CG 006 Tw
NINGUNSAW PASS
BOUNDARY
08 CF 002 Tw
LOWER ISKUT T Rl S
08 CG 001 Tw
15024800 Tw
2
ISKUT CANYON DAMSITE
08 CG 004 Tw
SNIPPAKER CR
STIKINE RIVER
ISKUT RIVER
400
500
600
700
800
900
1000
1100
1200
1300
1400
1500
1600
1700

STATION NO.	SYMBOL	STATION NAME
08CA001	◩	SPATSIZI RIVER NEAR THE MOUTH
08CA002	◩	STIKINE RIVER BELOW SPATSIZI RIVER
08CA003	◩	PITMAN RIVER NEAR THE MOUTH
08CB001	■	STIKINE RIVER ABOVE GRAND CANYON
08CC001	■	KLAPPAN RIVER NEAR TELEGRAPH CREEK
08CD001	■	TUYA RIVER NEAR TELEGRAPH CREEK
08CE001	■	STIKINE RIVER AT TELEGRAPH CREEK
08CF001	■	STIKINE RIVER ABOVE BUTTERFLY CREEK
08CF002	◩	STIKINE RIVER ABOVE CHOQUETTE RIVER
08CG[illegible]	■	ISKUT RIVER BELOW JOHNSON RIVER
08CG003	■	ISKUT RIVER AT OUTLET OF KINASKAN LAKE
08CG004	■	ISKUT RIVER ABOVE SNIPPAKER CREEK
08CG005	■	MORE CREEK NEAR THE MOUTH
08CG006	■	FORREST KERR CREEK ABOVE 460 m CONTOUR
	☐ 1	CHUTINE RIVER BELOW WRIGGLE CREEK
	☐ 2	CRAIG RIVER NEAR THE MOUTH


CASSIAR
MOUNTAINS
TUCHO
TRbPS
STIKINE - ISKUT
DRAINAGE BASIN
PITMAN
TRfPS
FROG RIVER
TRbPS
08CA003
08CA002
Tw
08CA001
CHUKACHIDA
TRbPS
DARSON
TPS
800
PULPIT LAKE
UPPER STIKINE
TRfPS
TRYGVE LAKE


STIKINE
BASIN
YUKON
TAKU
LIARD
STIKINE
NASS
ALBERTA
PEACE
SKEENA
QUEEN CHARLOTTE ISLANDS
FRASER
SW COASTAL
PACIFIC
OCEAN
VANCOUVER
ISLAND
COLUMBIA
U.S.A.

KEY PLAN

LEGEND:

T	THERMOGRAPH & MAXIMUM - MINIMUM THERMOMETER
Rb	BELFORT RECORDING RAIN GAUGE
Rf	FISHER-PORTER RECORDING RAIN GAUGE
P	STANDARD RAIN GAUGE
S	SNOW STAKES
W	ANEMOMETER
L	SOLARIMETER
▲	B.C. HYDRO/A.S.B. AUTOMATIC CLIMATOLOGICAL NETWORK STATIONS INSTALLED IN JUNE 1979
▼	B.C. HYDRO/A.S.B. AUTOMATIC CLIMATOLOGICAL NETWORK STATIONS INSTALLED IN SPRING 1981
△	AES MANUAL CLIMATOLOGICAL STATIONS INSTALLED PREVIOUS TO 1979
●	WATER INVESTIGATIONS BRANCH SNOW COURSE INSTALLED IN JUNE 1979
○	WATER INVESTIGATIONS BRANCH SNOW COURSE INSTALLED PREVIOUS TO 1979
■	WATER SURVEY OF CANADA GAUGING STATION
◪	WATER SURVEY OF CANADA GAUGING STATION STATIONS INSTALLED AFTER AUGUST 1980.
X	USGS GAUGING STATION
☐	B.C. HYDRO METERING SECTION
Tw	WATER TEMPERATURE THERMOGRAPH AT WSC OR USGS GAUGING STATION
	RESERVOIR
—800	ISOHYETAL LINE mm/yr

0 10 20 30 40 50 km

SCALE

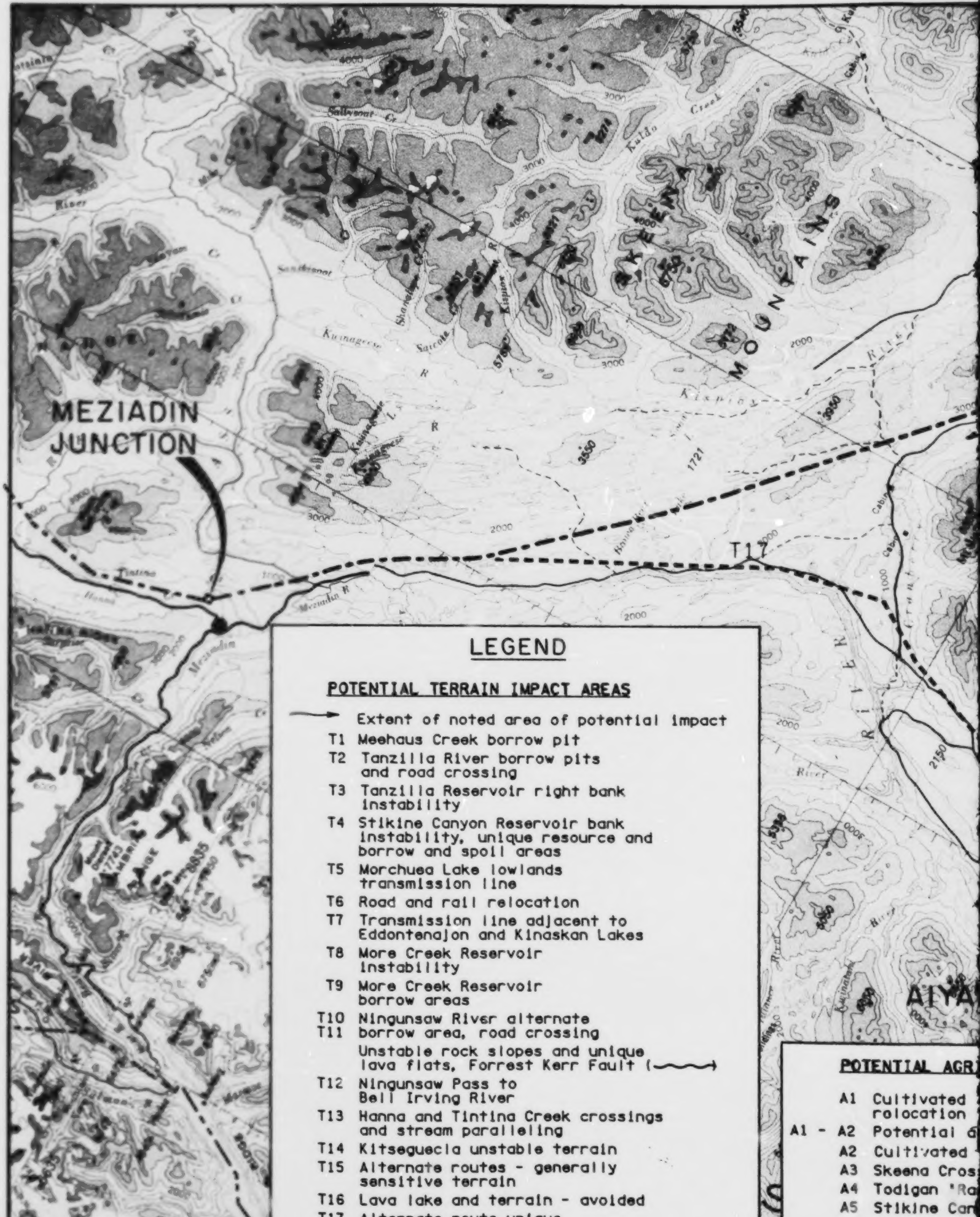
STATION NO.	SYMBOL	STATION NAME
08CA001	◪	SPATSIZI RIVER NEAR THE MOUTH
08CA002	◪	STIKINE RIVER BELOW SPATSIZI RIVER
08CA003	◪	PITMAN RIVER NEAR THE MOUTH
08CB001	■	STIKINE RIVER ABOVE GRAND CANYON
08CC001	■	KLAPPAN RIVER NEAR TELEGRAPH CREEK
08CD001	■	TUYA RIVER NEAR TELEGRAPH CREEK
08CE001	■	STIKINE RIVER AT TELEGRAPH CREEK
08CF001	■	STIKINE RIVER ABOVE BUTTERFLY CREEK
08CF002	◪	STIKINE RIVER ABOVE CHOQUETTE RIVER
08CG001	■	ISKUT RIVER BELOW JOHNSON RIVER
08CG003	■	ISKUT RIVER AT OUTLET OF KINASKAN LAKE
08CG004	■	ISKUT RIVER ABOVE SNIPPAKER CREEK
08CG005	■	MORE CREEK NEAR THE MOUTH
08CG006	■	FORREST KERR CREEK ABOVE 460 m CONTOUR
	☐ 1	CHUTINE RIVER BELOW WRIGGLE CREEK
	☐ 2	CRAIG RIVER NEAR THE MOUTH

B.C. HYDRO

FIGURE 5-2

STIKINE-ISKUT DEVELOPMENT
INTERIM ASSESSMENT
CLIMATOLOGICAL & HYDROLOGICAL STATIONS
MEAN ANNUAL PRECIPITATION

NOVEMBER, 1984


MEZIADIN JUNCTION
SKEENA MOUNTAINS
T17
AIYA
Kispiox
Kuldo Creek
Meziadin R
Hanna
Tintina
Kuinageese
River
3000
2000

LEGEND

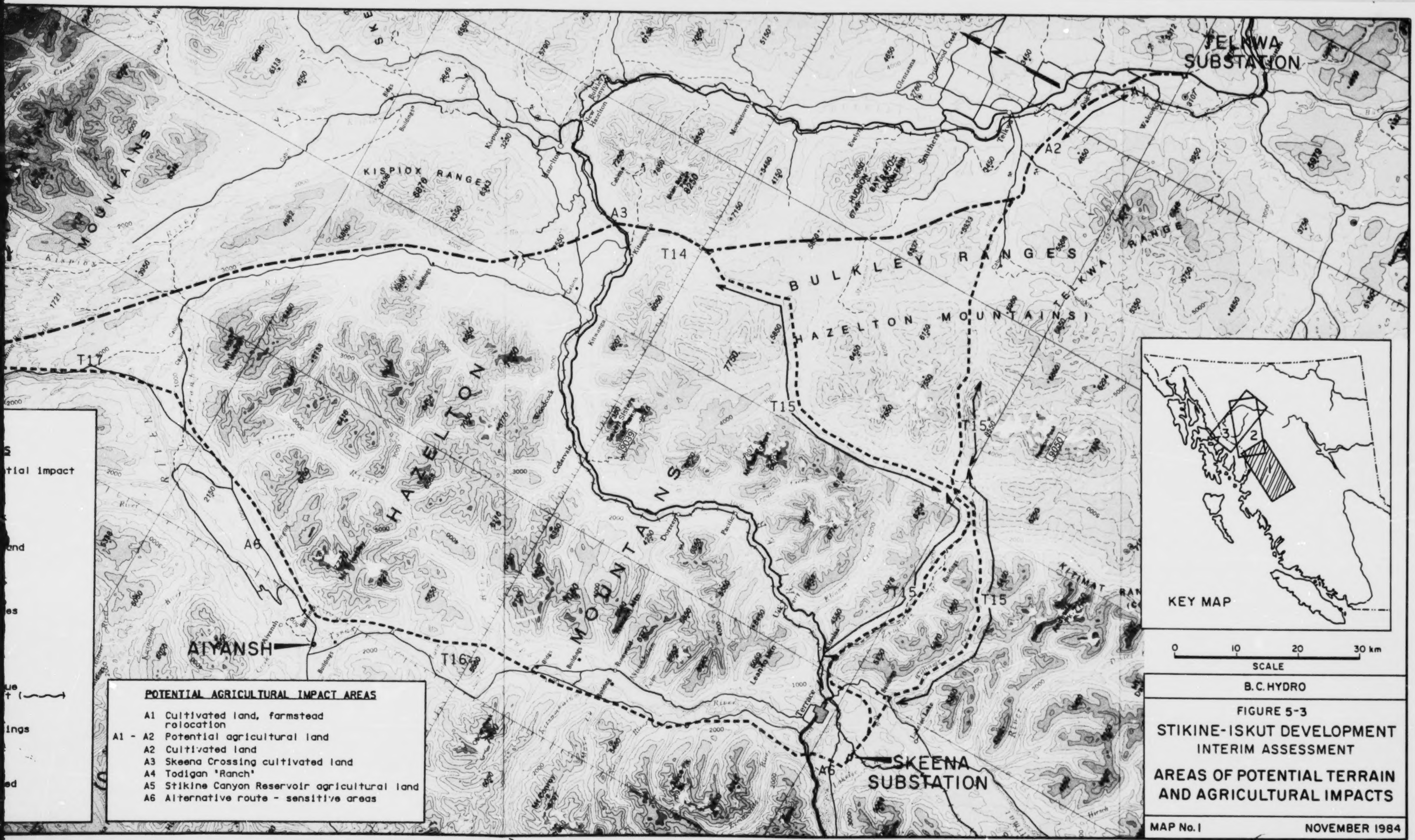
POTENTIAL TERRAIN IMPACT AREAS

→ Extent of noted area of potential impact

T1	Meehaus Creek borrow pit
T2	Tanzilla River borrow pits and road crossing
T3	Tanzilla Reservoir right bank instability
T4	Stikine Canyon Reservoir bank instability, unique resource and borrow and spoil areas
T5	Morchuea Lake lowlands transmission line
T6	Road and rail relocation
T7	Transmission line adjacent to Eddontenajon and Kinaskan Lakes
T8	More Creek Reservoir instability
T9	More Creek Reservoir borrow areas
T10	Ningunsaw River alternate
T11	borrow area, road crossing
	Unstable rock slopes and unique lava flats, Forrest Kerr Fault (〰→)
T12	Ningunsaw Pass to Bell Irving River
T13	Hanna and Tintina Creek crossings and stream paralleling
T14	Kitseguecla unstable terrain
T15	Alternate routes - generally sensitive terrain
T16	Lava lake and terrain - avoided
T17	Alternate route unique Kettle Volcanics

POTENTIAL AGR

A1	Cultivated rolocation
A1 - A2	Potential
A2	Cultivated
A3	Skeena Cros
A4	Todigan 'Ra
A5	Stikine Can
A6	Alternative


TELKWA SUBSTATION
A1
A2
A3
T14
T15
T16
T17
A6
AIYANSH
SKEENA SUBSTATION
KISPIOX RANGE
BULKLEY RANGES
HAZELTON MOUNTAINS
TELKWA RANGE
KITIMAT RANGES
MOUNTAINS
HAZELTON MOUNTAINS
New Hazelton
Smithers
Telkwa
Terrace
Kispiox
Cedarvale
Kitwanga
KEY MAP
3
2
0 10 20 30 km
SCALE
tial impact
and
es
ings
ed

POTENTIAL AGRICULTURAL IMPACT AREAS

A1	Cultivated land, farmstead rolocation
A1 - A2	Potential agricultural land
A2	Cultivated land
A3	Skeena Crossing cultivated land
A4	Todigan 'Ranch'
A5	Stikine Canyon Reservoir agricultural land
A6	Alternative route - sensitive areas

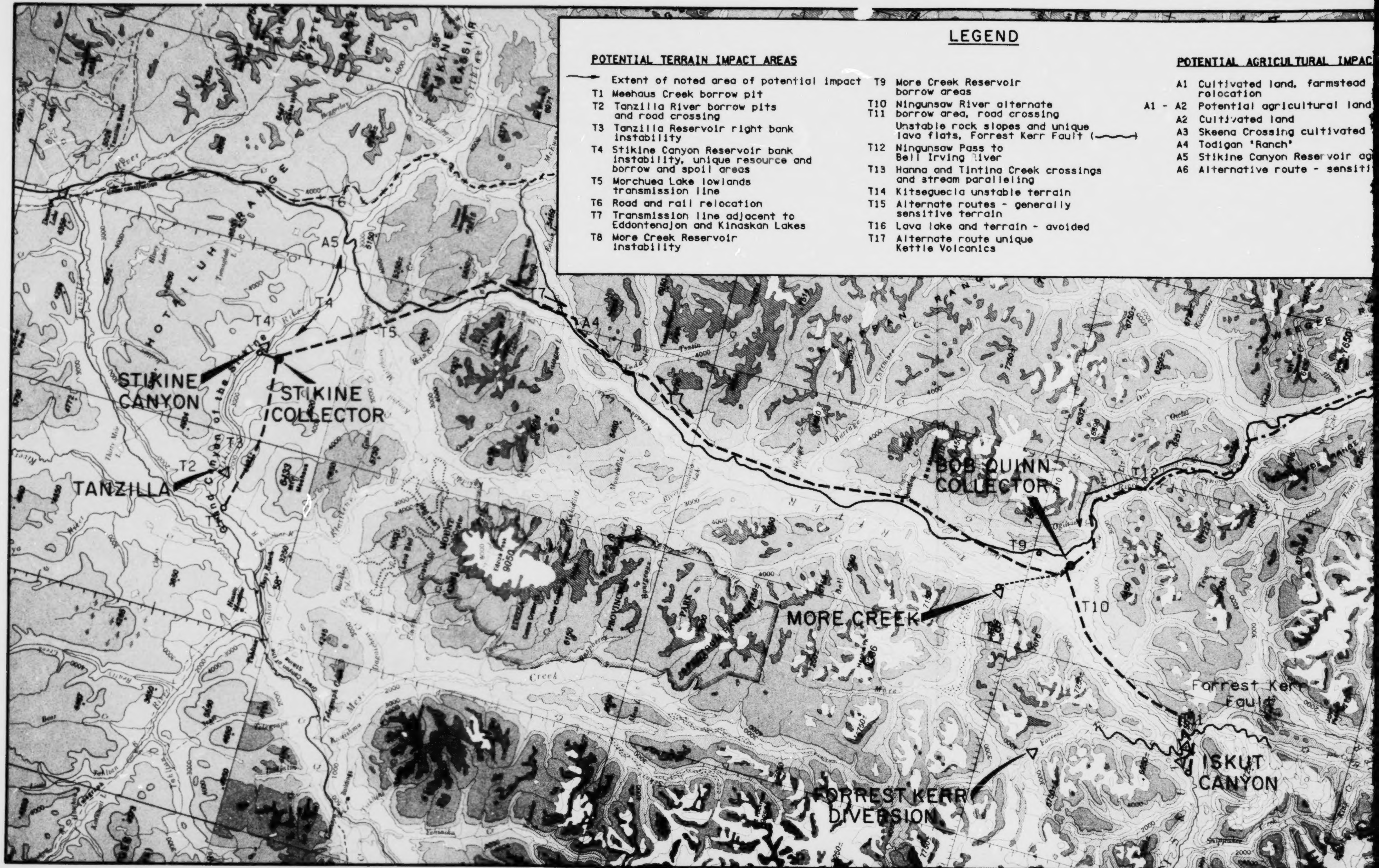
B.C. HYDRO

FIGURE 5-3

STIKINE-ISKUT DEVELOPMENT
INTERIM ASSESSMENT

AREAS OF POTENTIAL TERRAIN AND AGRICULTURAL IMPACTS

MAP No. 1 NOVEMBER 1984


STIKINE CANYON
STIKINE COLLECTOR
TANZILLA
BOB QUINN COLLECTOR
MORE CREEK
FORREST KERR DIVERSION
ISKUT CANYON
Forrest Kerr Fault
T1
T2
T3
T4
T5
T6
T7
T9
T10
T12
A4
A5
HOTAILUH RANGE
Grand Canyon of the Stikine
9050

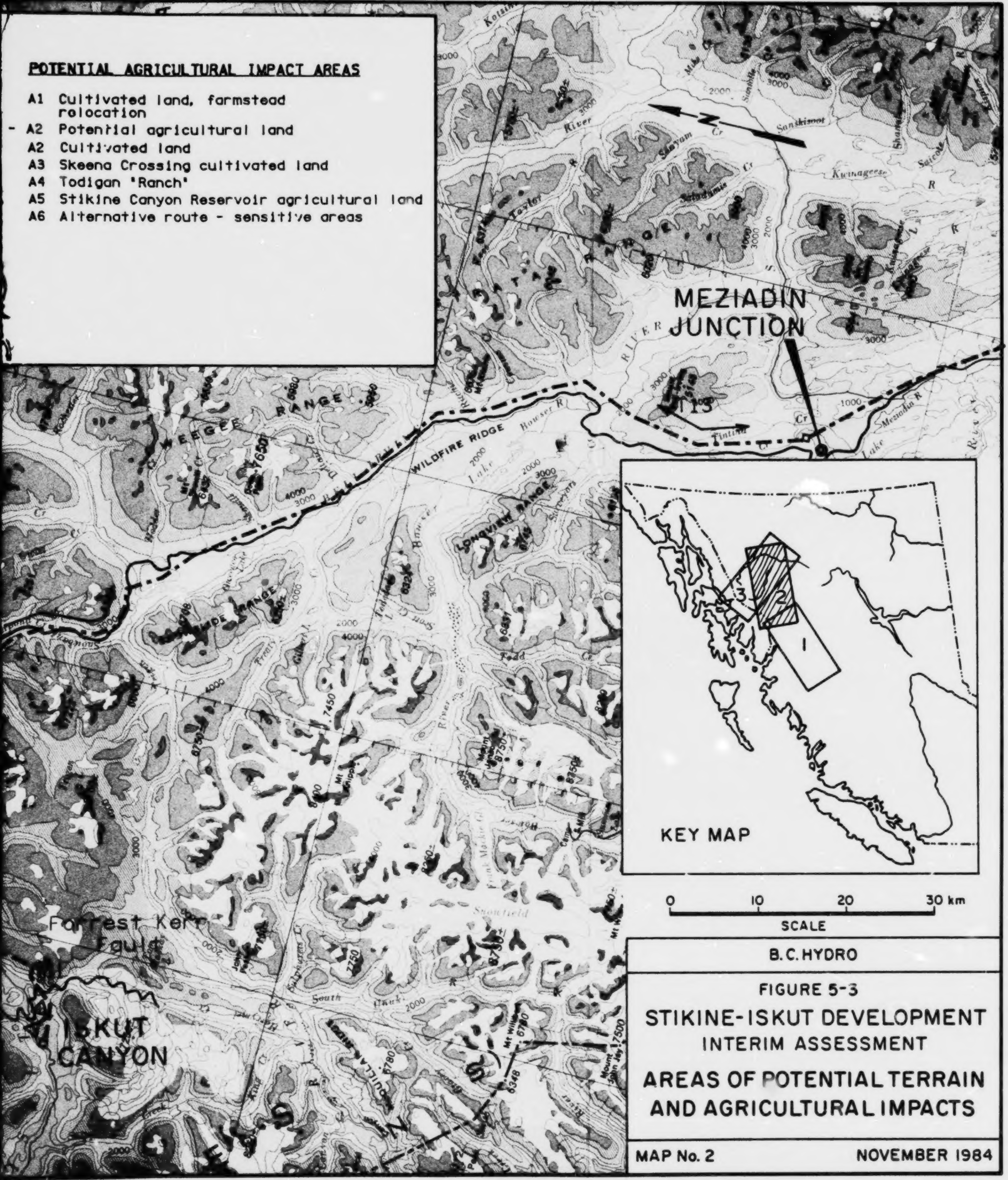
LEGEND

POTENTIAL TERRAIN IMPACT AREAS

→ Extent of noted area of potential impact
- T1 Meehaus Creek borrow pit
- T2 Tanzilla River borrow pits and road crossing
- T3 Tanzilla Reservoir right bank instability
- T4 Stikine Canyon Reservoir bank instability, unique resource and borrow and spoil areas
- T5 Morchuea Lake lowlands transmission line
- T6 Road and rail relocation
- T7 Transmission line adjacent to Eddontenajon and Kinaskan Lakes
- T8 More Creek Reservoir instability
- T9 More Creek Reservoir borrow areas
- T10 Ningunsaw River alternate
- T11 borrow area, road crossing
  Unstable rock slopes and unique lava flats, Forrest Kerr Fault (〰→)
- T12 Ningunsaw Pass to Bell Irving River
- T13 Hanna and Tintina Creek crossings and stream paralleling
- T14 Kitseguecla unstable terrain
- T15 Alternate routes - generally sensitive terrain
- T16 Lava lake and terrain - avoided
- T17 Alternate route unique Kettle Volcanics

POTENTIAL AGRICULTURAL IMPAC

- A1 Cultivated land, farmstead relocation
- A1 - A2 Potential agricultural land
- A2 Cultivated land
- A3 Skeena Crossing cultivated
- A4 Todigan "Ranch"
- A5 Stikine Canyon Reservoir ag
- A6 Alternative route - sensiti


MEZIADIN JUNCTION
WEEGEE RANGE
WILDFIRE RIDGE
LONGVIEW RANGE
Bowser R
Lake
Meziadin R
Tintina Cr
Kwinageese R
Sanskisoot Cr
River
Snowfield
South Unuk
Forrest Kerr Fault
ISKUT CANYON
A13
KEY MAP
1
2
3
0
10
20
30 km
SCALE

POTENTIAL AGRICULTURAL IMPACT AREAS

- A1 Cultivated land, farmstead relocation
- A2 Potential agricultural land
- A2 Cultivated land
- A3 Skeena Crossing cultivated land
- A4 Todigan 'Ranch'
- A5 Stikine Canyon Reservoir agricultural land
- A6 Alternative route - sensitive areas

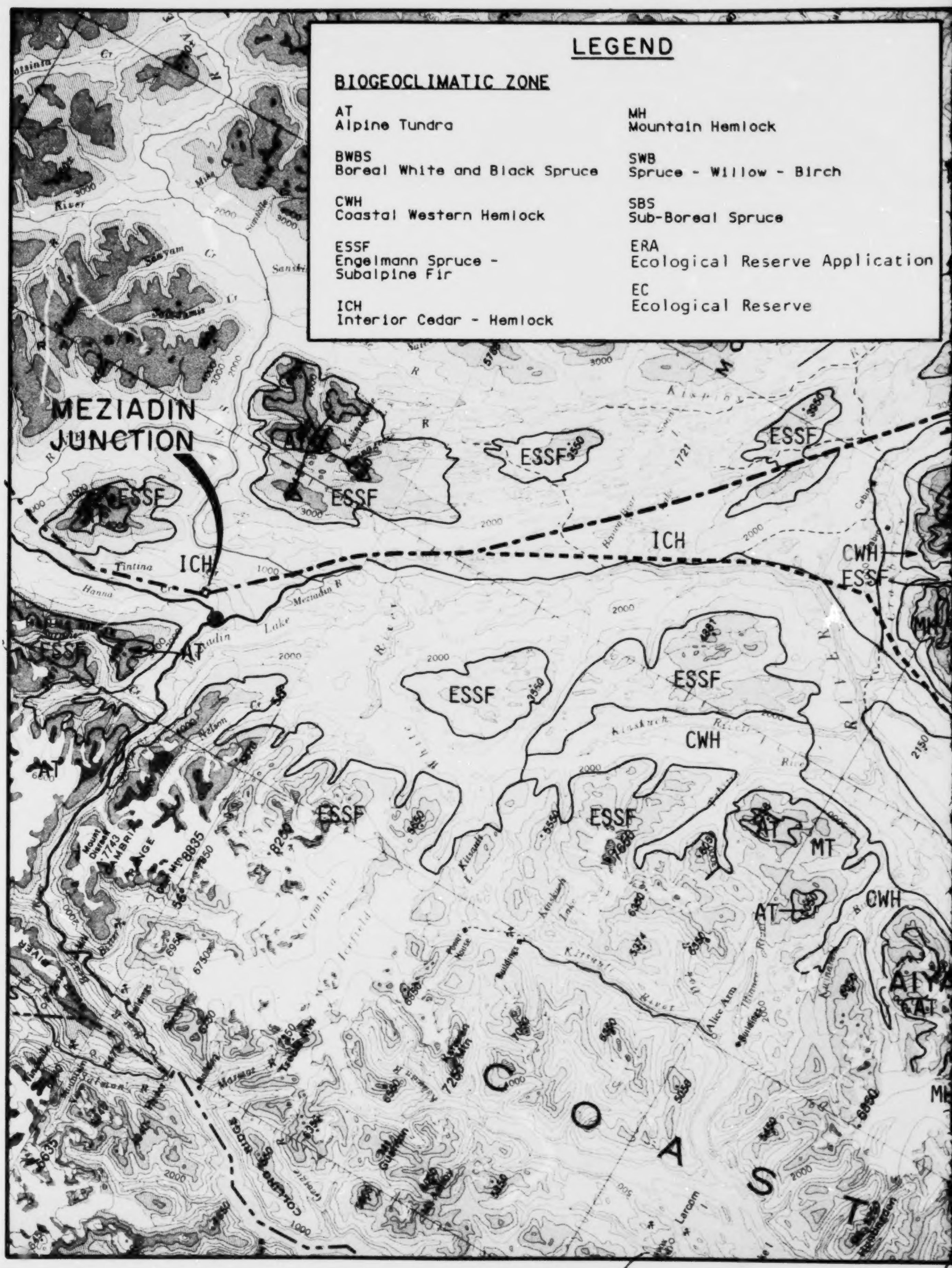
B.C. HYDRO

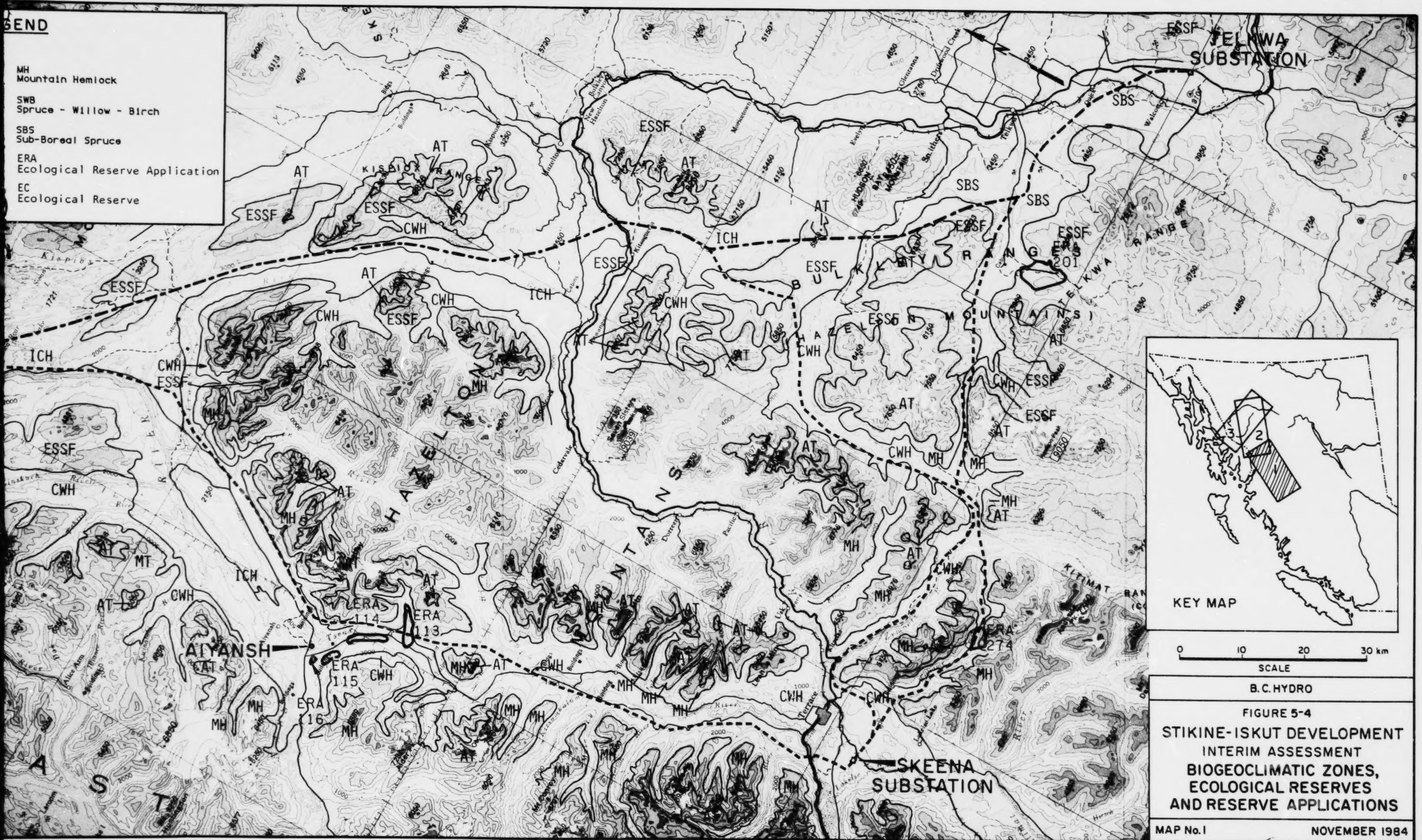
FIGURE 5-3

STIKINE-ISKUT DEVELOPMENT
INTERIM ASSESSMENT

AREAS OF POTENTIAL TERRAIN AND AGRICULTURAL IMPACTS

MAP No. 2 NOVEMBER 1984


LEGEND
BIOGEOCLIMATIC ZONE
AT Alpine Tundra
BWBS Boreal White and Black Spruce
CWH Coastal Western Hemlock
ESSF Engelmann Spruce - Subalpine Fir
ICH Interior Cedar - Hemlock
MH Mountain Hemlock
SWB Spruce - Willow - Birch
SBS Sub-Boreal Spruce
ERA Ecological Reserve Application
EC Ecological Reserve
MEZIADIN JUNCTION
ESSF
ICH
AT
CWH
MH
MT
Meziadin Lake
Meziadin R
Tintina
Hanna
Kinskuch
Kitsault
Alice Arm
COAST
CAMBRIA RANGE
COLUMBIA RIDGE
Larcom
2000
3000
1000



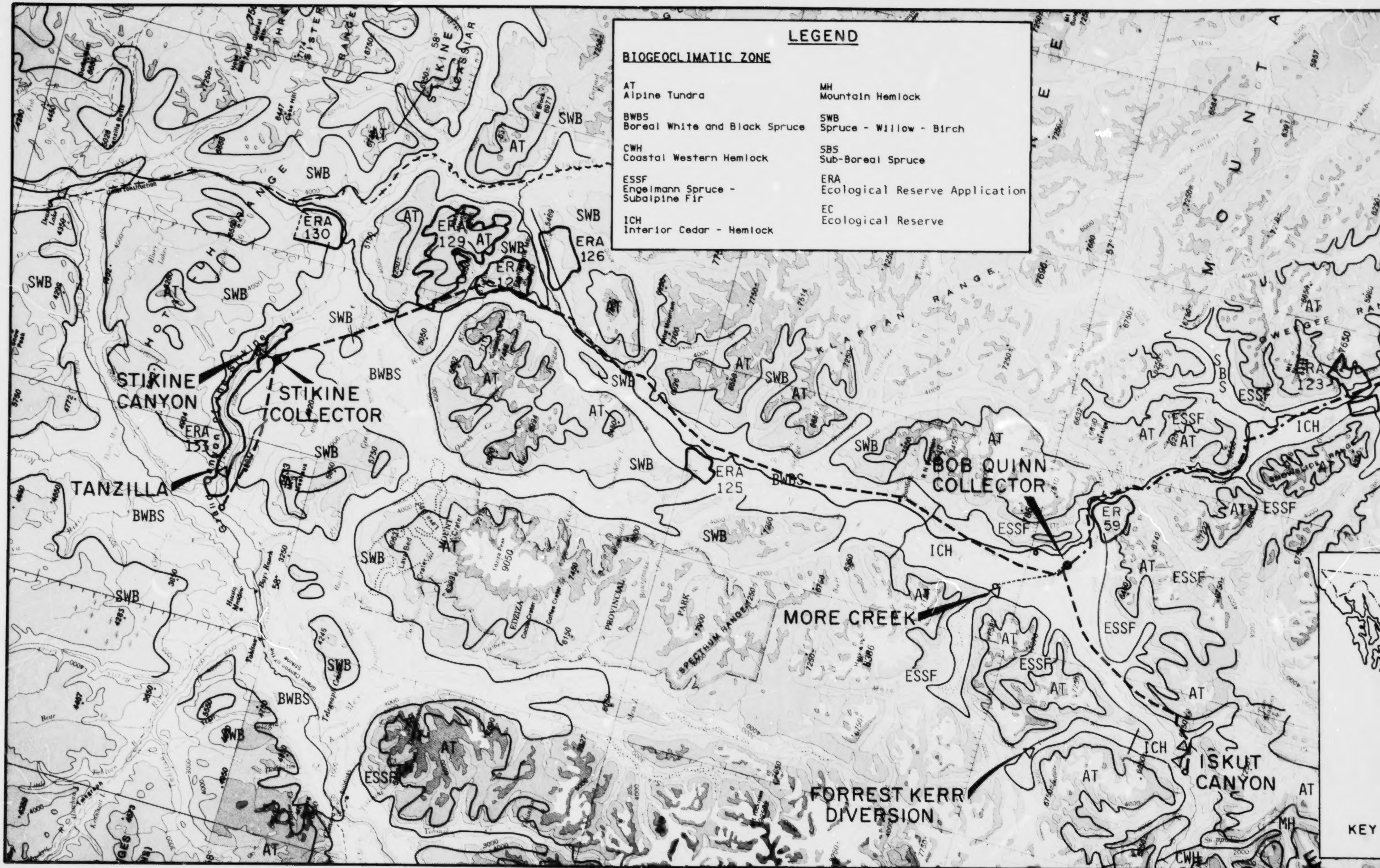
GEND
MH Mountain Hemlock
SWB Spruce - Willow - Birch
SBS Sub-Boreal Spruce
ERA Ecological Reserve Application
EC Ecological Reserve
TELKWA SUBSTATION
SKEENA SUBSTATION
AIYANSH
KISPIOX RANGE
BULKLEY RANGES
HAZELTON MOUNTAINS
TELKWA RANGE
KITIMAT RANGES
ERA 114
ERA 113
ERA 115
ERA 116
ERA 274
201
AT
ESSF
CWH
ICH
SBS
MH
MT
KEY MAP
1
2
3
0 10 20 30 km
SCALE

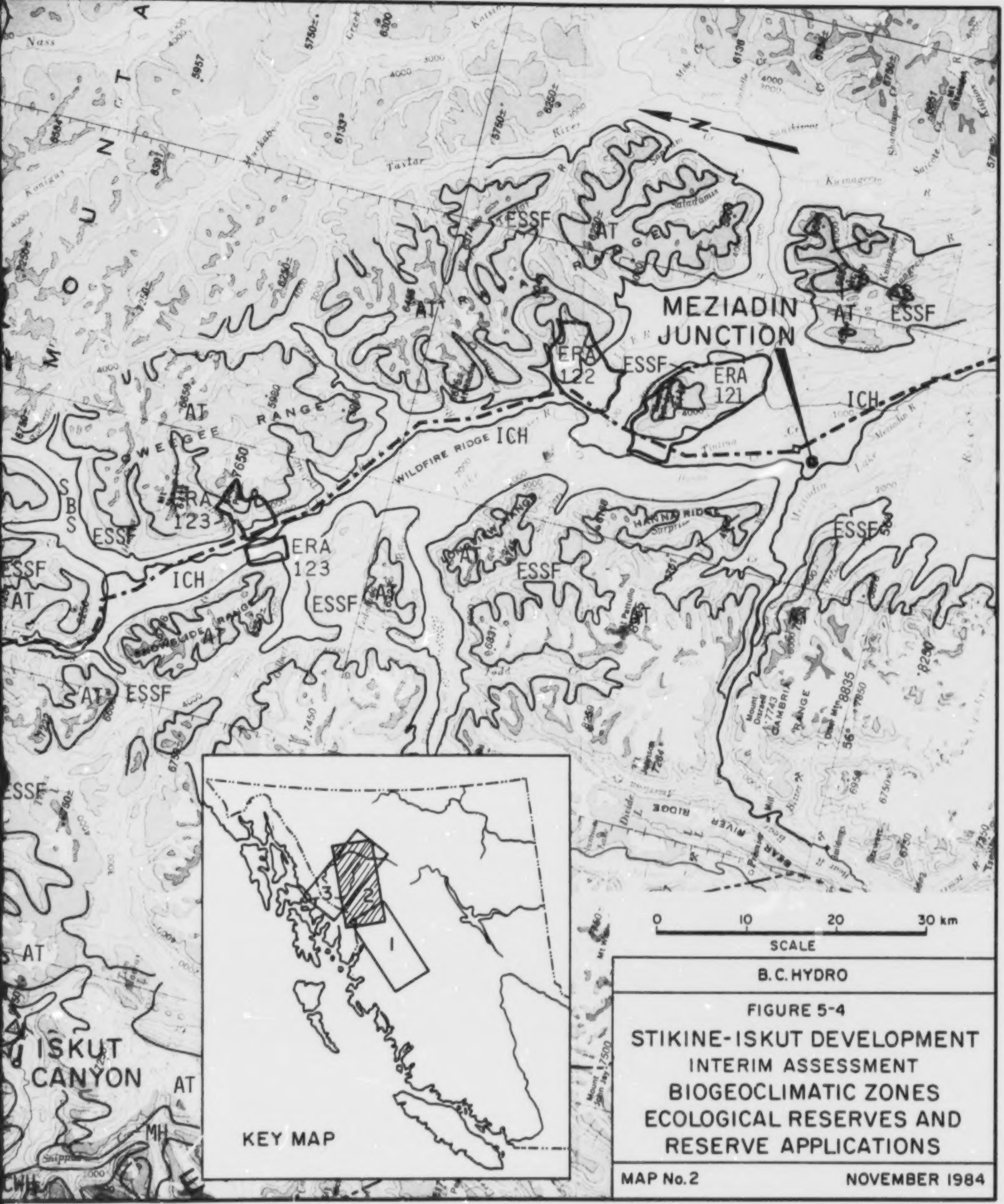
B.C. HYDRO

FIGURE 5-4

STIKINE-ISKUT DEVELOPMENT
INTERIM ASSESSMENT
BIOGEOCLIMATIC ZONES,
ECOLOGICAL RESERVES
AND RESERVE APPLICATIONS

MAP No. 1 NOVEMBER 1984


LEGEND
BIOGEOCLIMATIC ZONE
AT
Alpine Tundra
BWBS
Boreal White and Black Spruce
CWH
Coastal Western Hemlock
ESSF
Engelmann Spruce - Subalpine Fir
ICH
Interior Cedar - Hemlock
MH
Mountain Hemlock
SWB
Spruce - Willow - Birch
SBS
Sub-Boreal Spruce
ERA
Ecological Reserve Application
EC
Ecological Reserve
STIKINE CANYON
STIKINE COLLECTOR
TANZILLA
ERA 130
ERA 129
ERA 128
ERA 126
ERA 131
ERA 125
ERA 123
ER 59
BOB QUINN COLLECTOR
MORE CREEK
FORREST KERR DIVERSION
ISKUT CANYON
KLAPPAN RANGE
SPECTRUM RANGE
PROVINCIAL PARK
EDZIZA
SNOWSLIDE RANGE
KEY



MEZIADIN JUNCTION
N
ERA 121
ERA 122
ERA 123
ERA 123
AT
ESSF
ICH
SBS
MH
CWH
WILDFIRE RIDGE
OWEEGEE RANGE
SNOWSLIDE RANGE
HANNA RIDGE
CAMBRIA RANGE
BEAR RIVER RIDGE
ISKUT CANYON
KEY MAP
1
2
3
0
10
20
30 km
SCALE

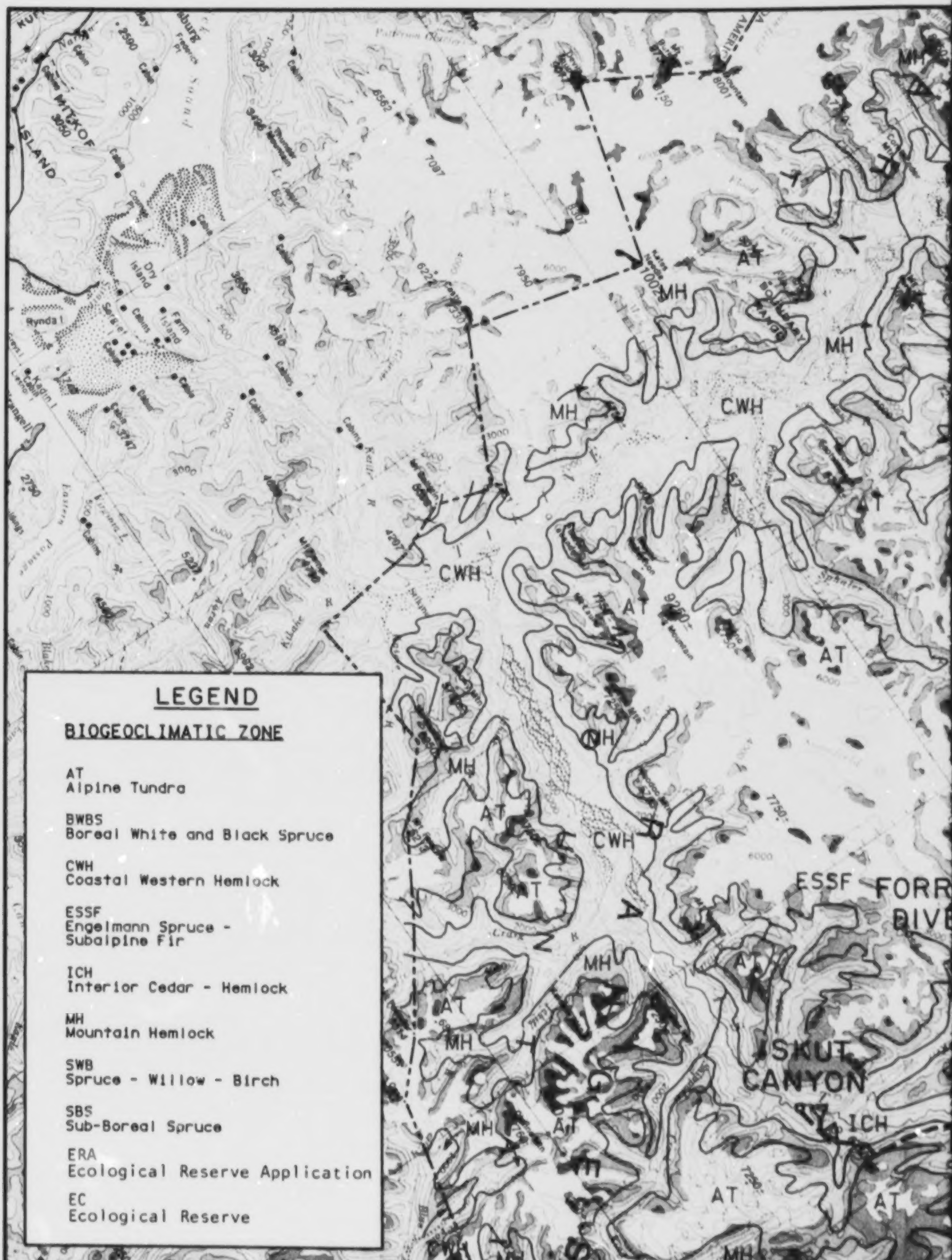
B.C. HYDRO

FIGURE 5-4

STIKINE-ISKUT DEVELOPMENT
INTERIM ASSESSMENT
BIOGEOCLIMATIC ZONES
ECOLOGICAL RESERVES AND
RESERVE APPLICATIONS

MAP No. 2

NOVEMBER 1984


LEGEND
BIOGEOCLIMATIC ZONE
AT
Alpine Tundra
BWBS
Boreal White and Black Spruce
CWH
Coastal Western Hemlock
ESSF
Engelmann Spruce - Subalpine Fir
ICH
Interior Cedar - Hemlock
MH
Mountain Hemlock
SWB
Spruce - Willow - Birch
SBS
Sub-Boreal Spruce
ERA
Ecological Reserve Application
EC
Ecological Reserve
MITKOF
ISLAND
Dry Island
Farm Island
Rynda I
MH
CWH
AT
ESSF
FORR
DIVE
ISKUT
CANYON
ICH

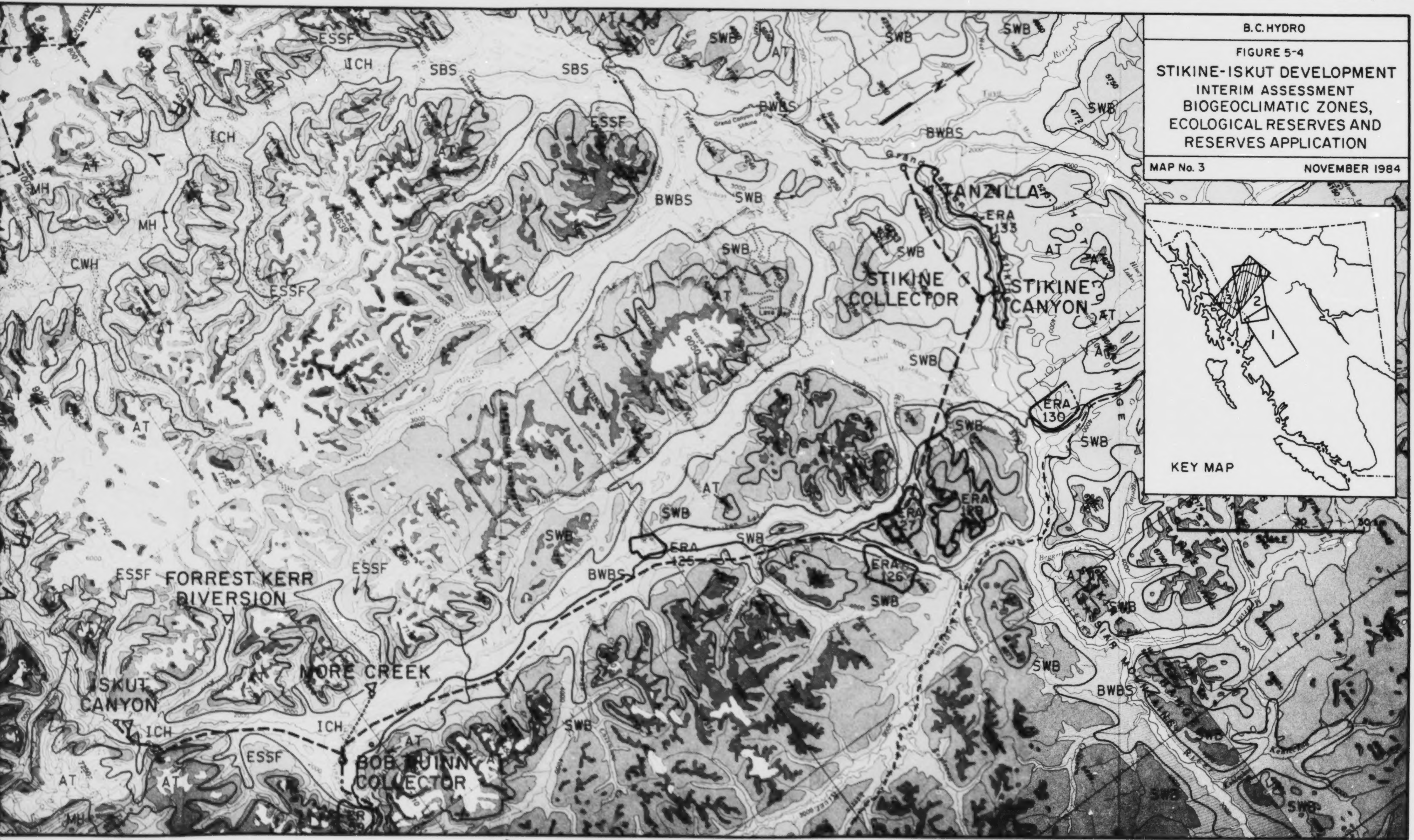
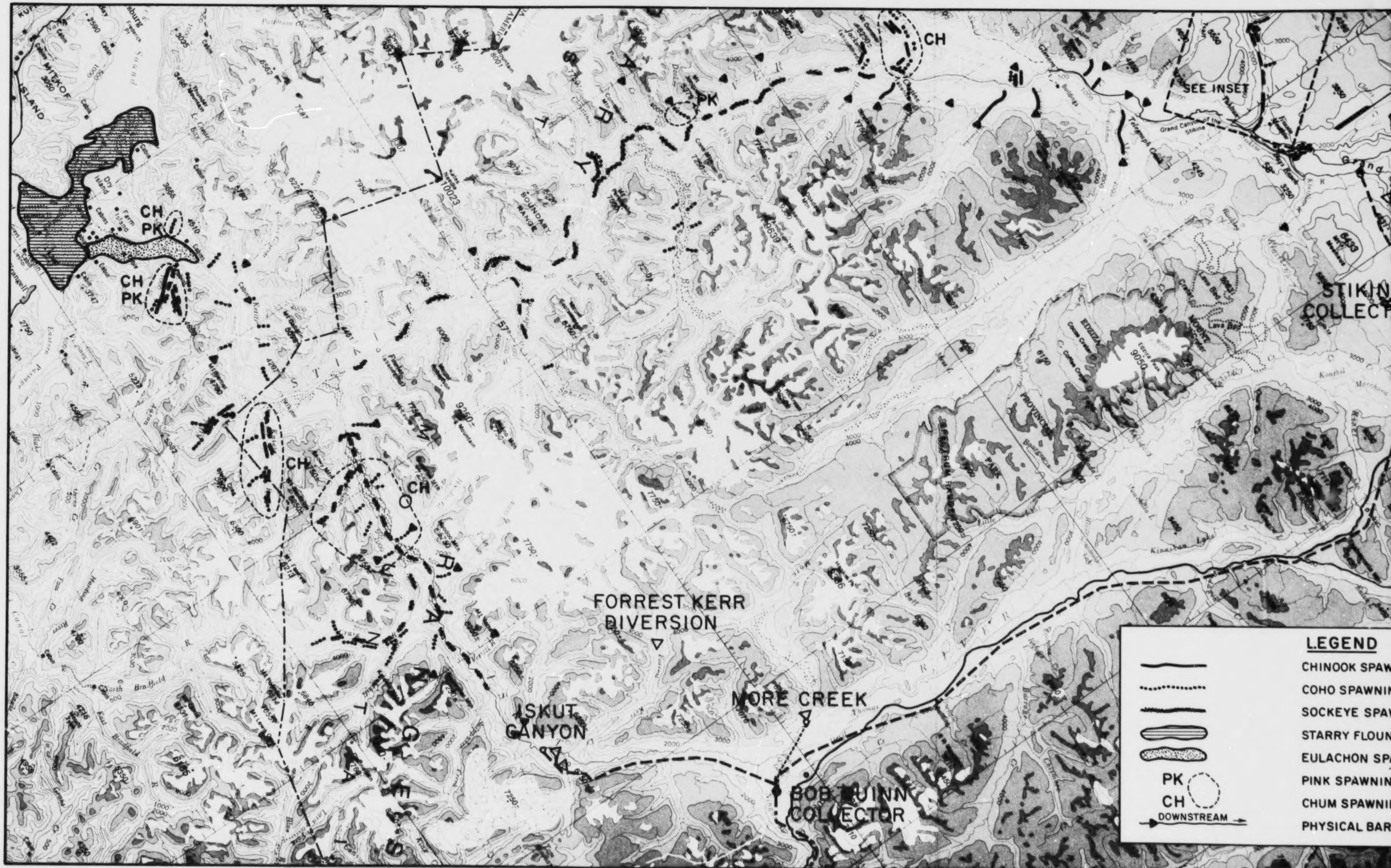

B.C. HYDRO

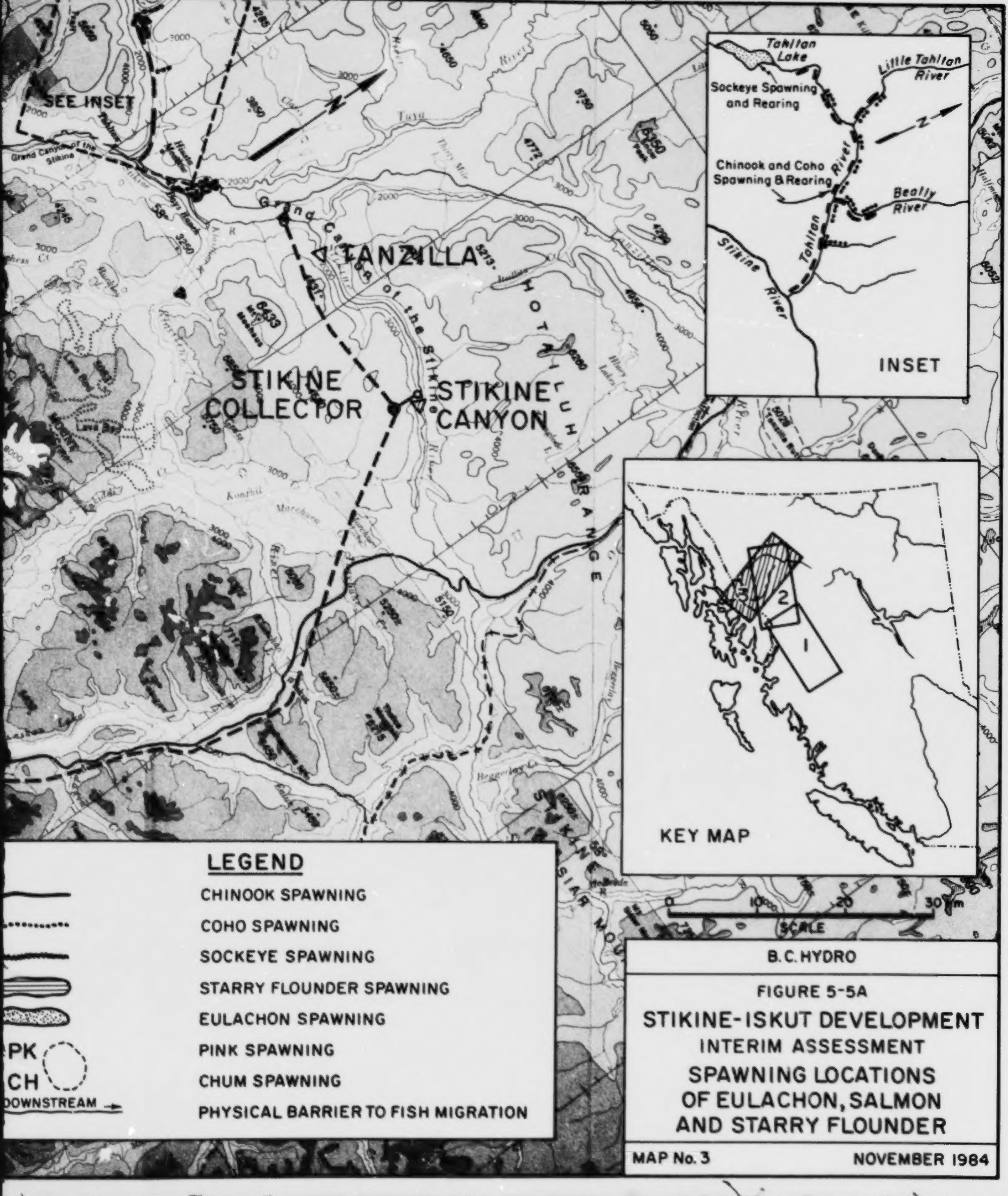
FIGURE 5-4

STIKINE-ISKUT DEVELOPMENT
INTERIM ASSESSMENT
BIOGEOCLIMATIC ZONES,
ECOLOGICAL RESERVES AND
RESERVES APPLICATION

MAP No. 3 NOVEMBER 1984

KEY MAP
1
2
3
SCALE
TANZILLA
ERA 133
STIKINE COLLECTOR
STIKINE CANYON
ERA 130
ERA 127
ERA 128
ERA 125
ERA 126
FORREST KERR DIVERSION
MORE CREEK
ISKUT CANYON
BOB QUINN COLLECTOR
AT
ESSF
ICH
SBS
SWB
BWBS
MH
CWH


CH
PK
CH
PK
CH
PK
CH
CH
SEE INSET
STIKIN
COLLECT
FORREST KERR
DIVERSION
MORE CREEK
ISKUT
CANYON
BOB QUINN
COLLECTOR
BOUNDARY RANGE
LEGEND
CHINOOK SPAW
COHO SPAWNIN
SOCKEYE SPAW
STARRY FLOUN
EULACHON SPA
PK
PINK SPAWNIN
CH
CHUM SPAWNI
DOWNSTREAM
PHYSICAL BAR


SEE INSET
Grand Canyon of the Stikine
TANZILLA
Grand Canyon of the Stikine
STIKINE COLLECTOR
STIKINE CANYON
HOTAILUH RANGE
Tuya River
Tahltan Lake
Little Tahltan River
Sockeye Spawning and Rearing
Chinook and Coho Spawning & Rearing
Tahltan River
Beatty River
Stikine River
N
INSET
KEY MAP
1
2
3
0
10
20
30 km
SCALE

LEGEND

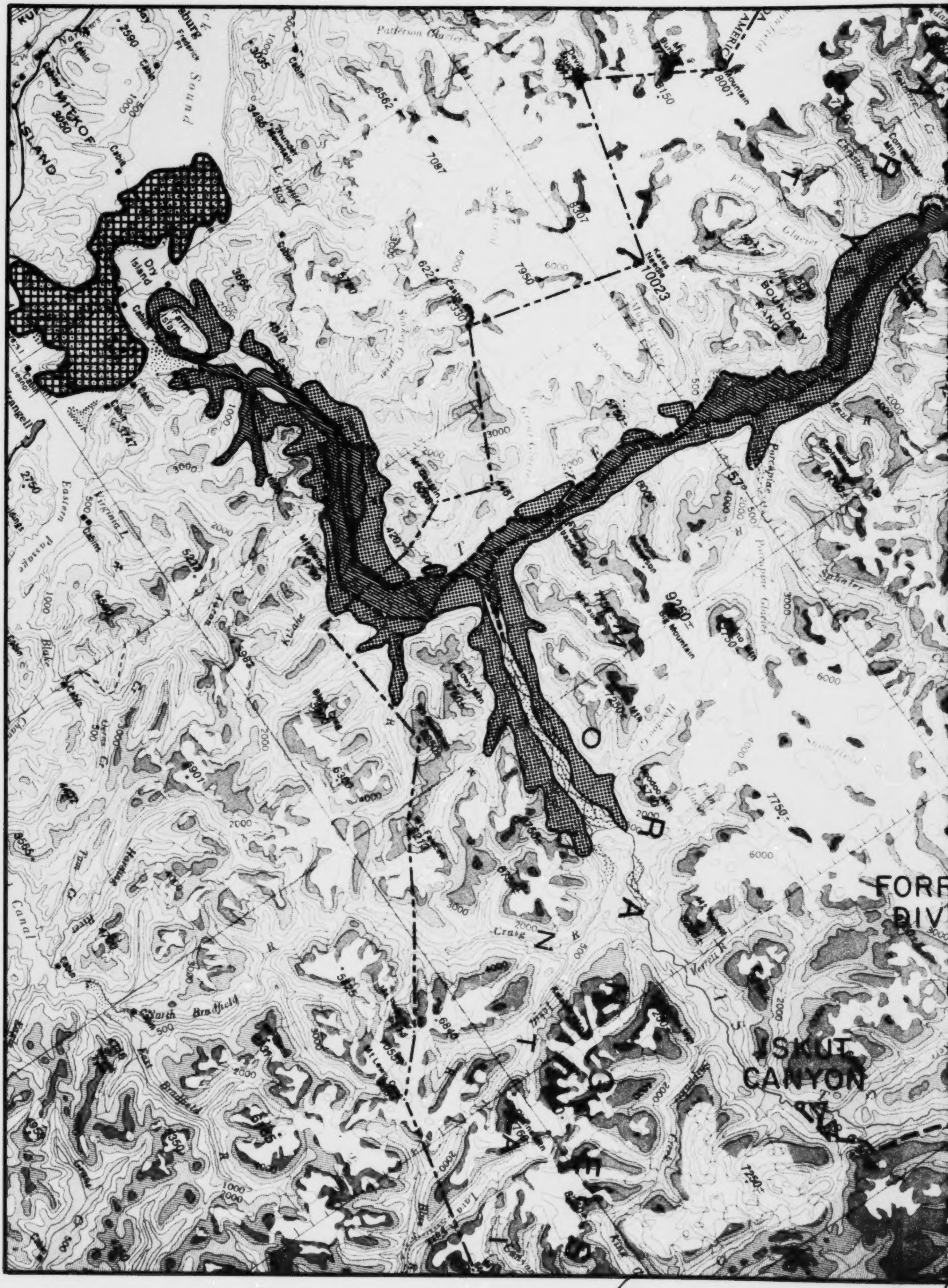
───	CHINOOK SPAWNING
········	COHO SPAWNING
───	SOCKEYE SPAWNING
▭	STARRY FLOUNDER SPAWNING
▨	EULACHON SPAWNING
PK ◌	PINK SPAWNING
CH ◌	CHUM SPAWNING
DOWNSTREAM →	PHYSICAL BARRIER TO FISH MIGRATION

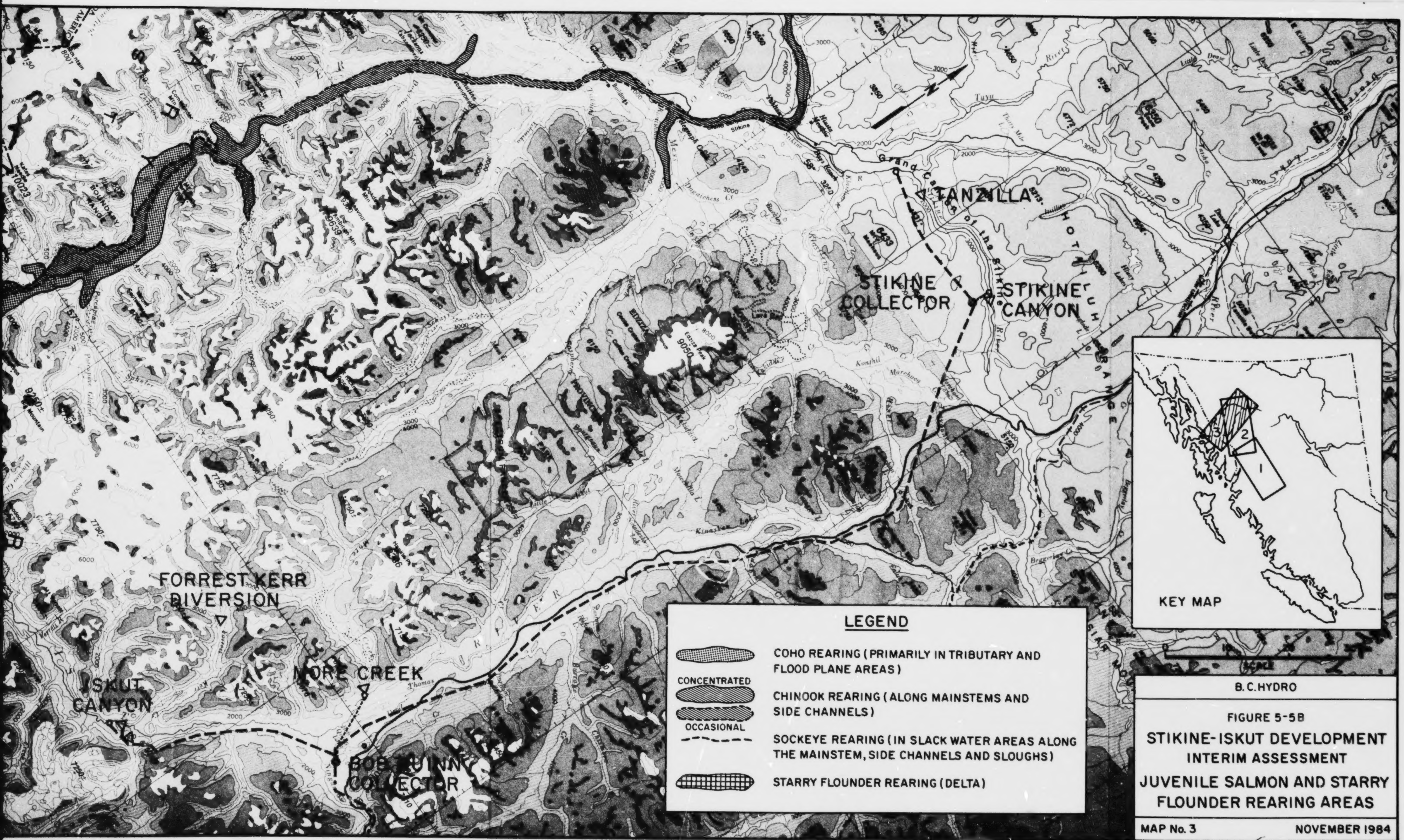
B.C. HYDRO

FIGURE 5-5A

STIKINE-ISKUT DEVELOPMENT
INTERIM ASSESSMENT
SPAWNING LOCATIONS
OF EULACHON, SALMON
AND STARRY FLOUNDER

MAP No. 3 NOVEMBER 1984

Patterson Glacier
Sound
MITKOF
ISLAND
3050
2590
3035
6562
7087
Frederick Pt
Dry Island
Farm Island
Eastern
Passage
Virginia I
Blake
Canal
North Bradfield
East Bradfield
Craig R
Verrett R
Flood Glacier
Porcupine Glacier
Great Glacier
Kates Needle
10023
BOUNDARY RANGE
Big Mountain
9250
7950
8307
8007
8150
6901
7750
ISKUT
CANYON
FORR
DIV
O
R
A
N
T


TANZILLA
STIKINE COLLECTOR
STIKINE CANYON
FORREST KERR DIVERSION
MORE CREEK
ISKUT CANYON
BOB QUINN COLLECTOR
KEY MAP
LEGEND
COHO REARING (PRIMARILY IN TRIBUTARY AND FLOOD PLANE AREAS)
CONCENTRATED
CHINOOK REARING (ALONG MAINSTEMS AND SIDE CHANNELS)
OCCASIONAL
SOCKEYE REARING (IN SLACK WATER AREAS ALONG THE MAINSTEM, SIDE CHANNELS AND SLOUGHS)
STARRY FLOUNDER REARING (DELTA)

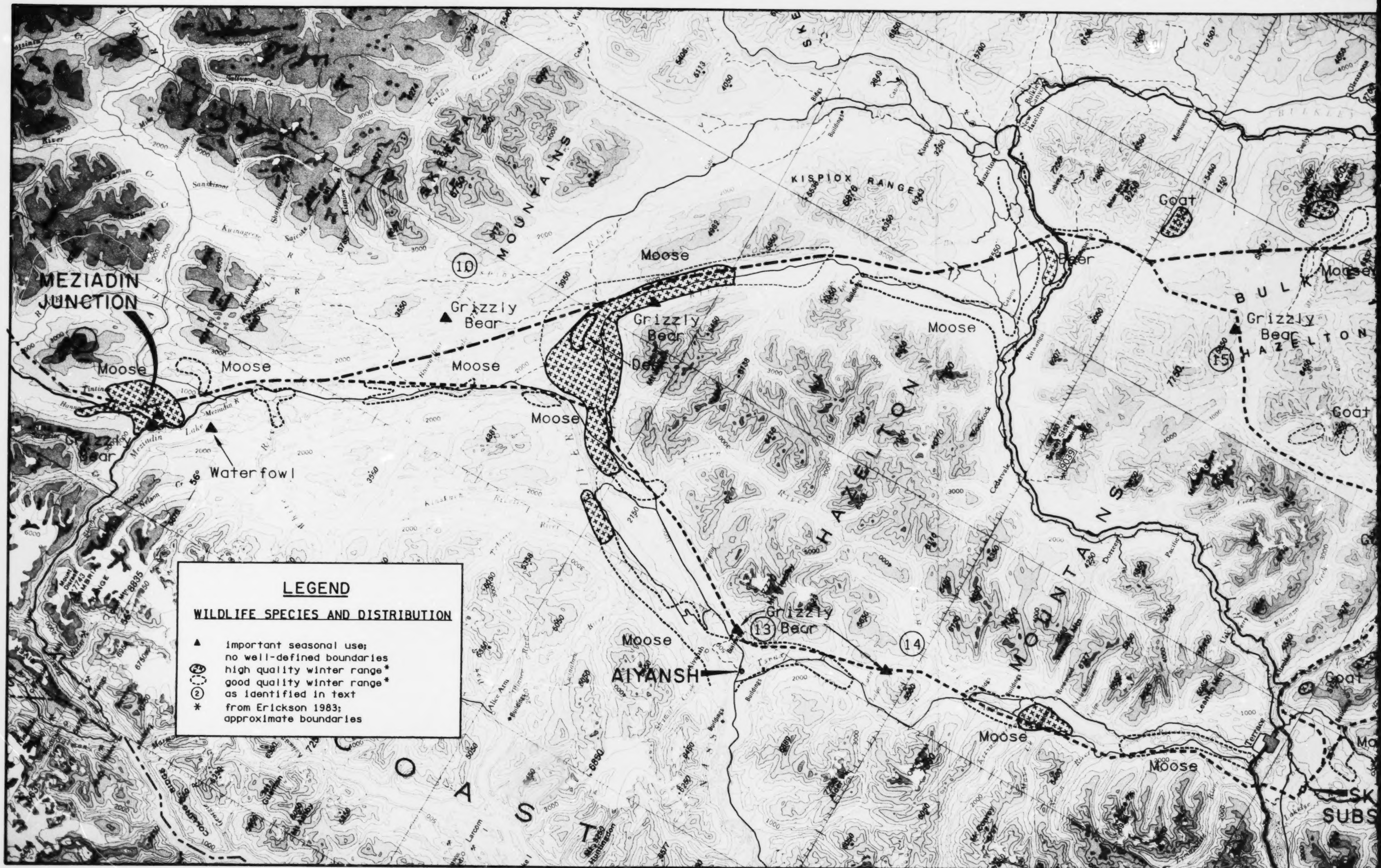
B.C.HYDRO

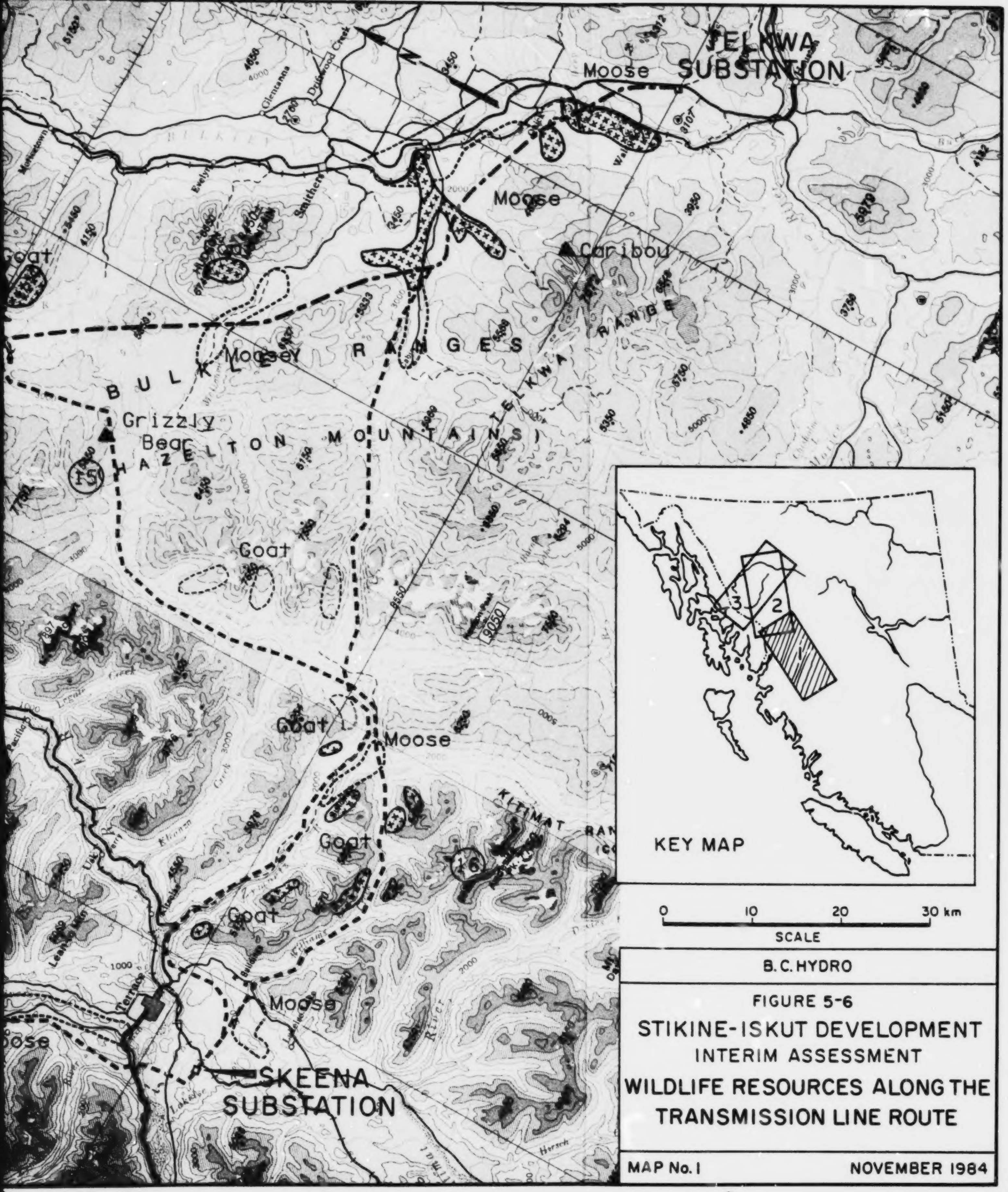
FIGURE 5-5B

STIKINE-ISKUT DEVELOPMENT
INTERIM ASSESSMENT

JUVENILE SALMON AND STARRY FLOUNDER REARING AREAS

MAP No. 3 NOVEMBER 1984


LEGEND
WILDLIFE SPECIES AND DISTRIBUTION
▲ important seasonal use; no well-defined boundaries
▨ high quality winter range*
good quality winter range*
② as identified in text
* from Erickson 1983; approximate boundaries
MEZIADIN JUNCTION
AIYANSH
SKEENA MOUNTAINS
KISPIOX RANGE
HAZELTON MOUNTAINS
COAST
BULKLEY
HAZELTON
Moose
Grizzly Bear
Waterfowl
Deer
Goat
10
13
14
15
Meziadin Lake
Hazelton
New Hazelton
Kitwanga
Cedarvale
Terrace
56°



TELKWA SUBSTATION
Moose
Moose
Caribou
Goat
Goat
BULKLEY RANGES
TELKWA RANGE
Moose
Grizzly Bear
HAZELTON MOUNTAINS
15
Goat
Goat
Moose
KITIMAT RANGES
Goat
16
Goat
Moose
Terrace
Smithers
Bulkley
SKEENA SUBSTATION
9050
KEY MAP
1
2
3
0
10
20
30 km
SCALE

B.C. HYDRO

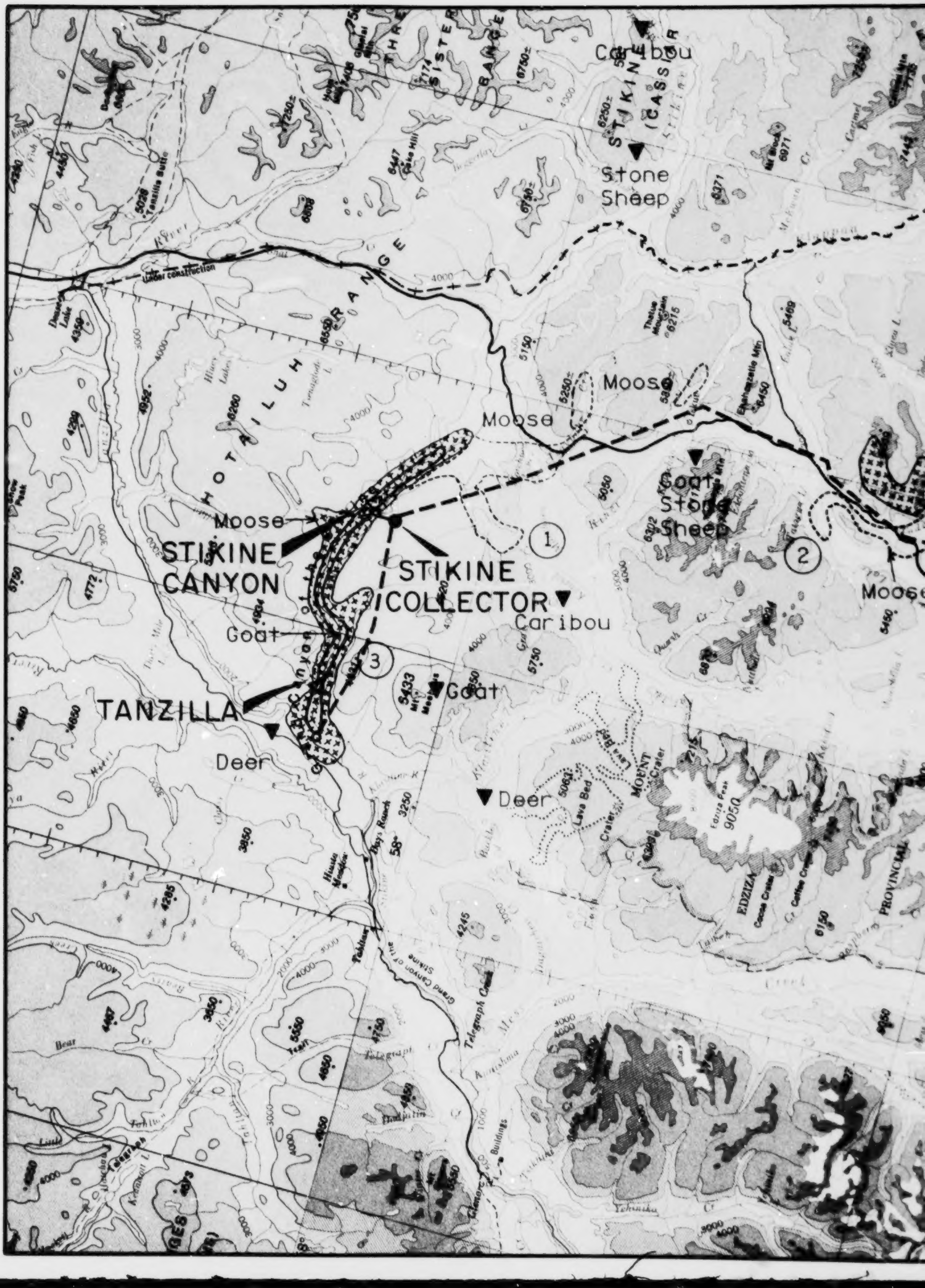
FIGURE 5-6

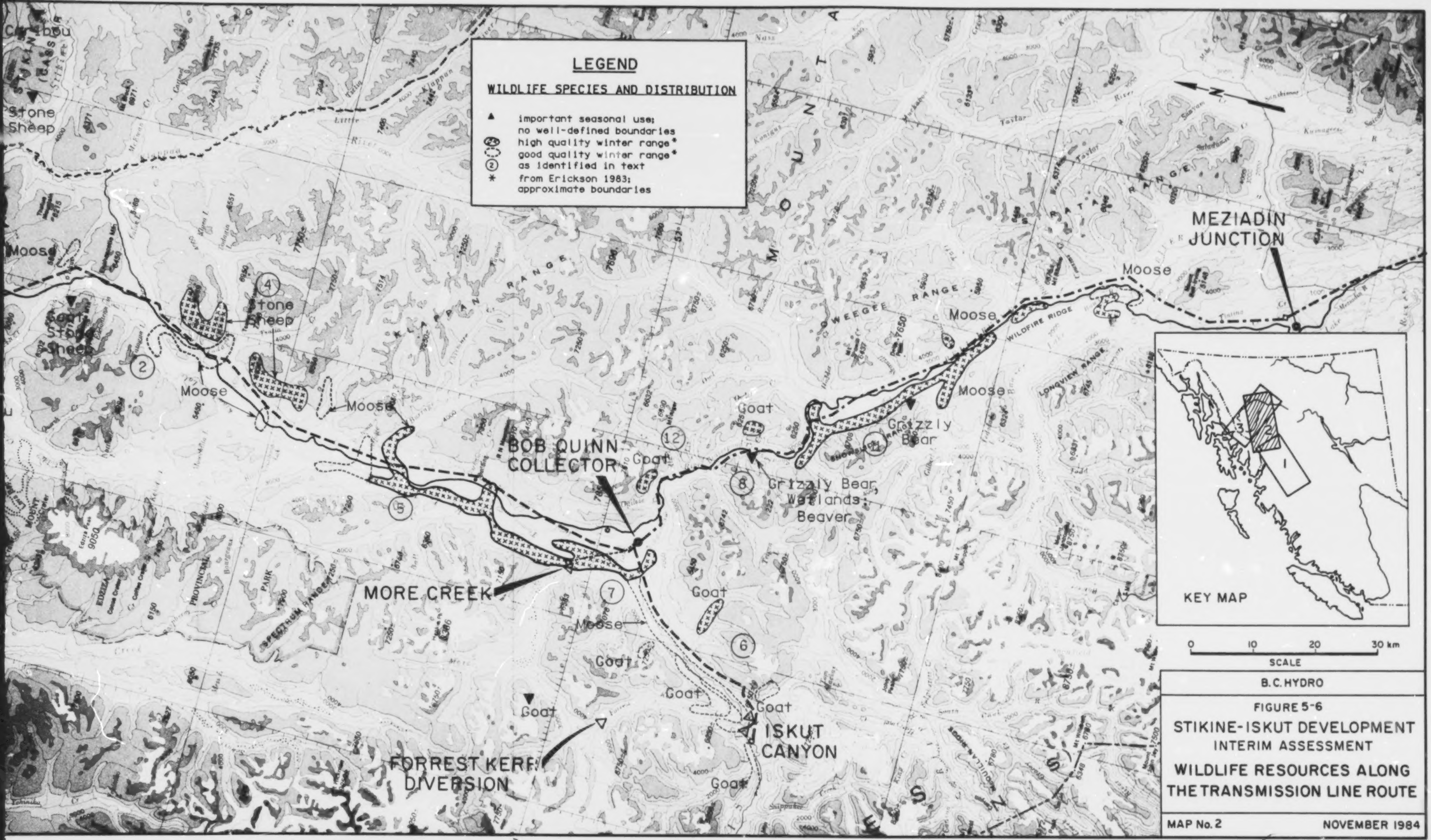
STIKINE-ISKUT DEVELOPMENT
INTERIM ASSESSMENT

WILDLIFE RESOURCES ALONG THE TRANSMISSION LINE ROUTE

MAP No. 1

NOVEMBER 1984


Caribou
Stone Sheep
THREE SISTERS RANGE
STIKINE (CASSIAR)
HOTAILUH RANGE
Moose
Moose
Moose
Goat
Stone Sheep
STIKINE CANYON
STIKINE COLLECTOR
Caribou
Moose
1
2
3
Goat
Goat
TANZILLA
Deer
Deer
Grand Canyon of the Stikine
Telegraph Creek
MOUNT EDZIZA
9050
PROVINCIAL
Under construction
Buildings
58°


LEGEND
WILDLIFE SPECIES AND DISTRIBUTION
▲ important seasonal use; no well-defined boundaries
high quality winter range*
good quality winter range*
② as identified in text
* from Erickson 1983; approximate boundaries
Caribou
Stone Sheep
Moose
Goat
Stone Sheep
②
④
Stone Sheep
Moose
Moose
KLAPPAN RANGE
⑤
BOB QUINN COLLECTOR
Goat
⑫
Goat
⑧
Grizzly Bear Wetlands; Beaver
OWEEGEE RANGE
Moose
Grizzly Bear
⑪
Moose
WILDFIRE RIDGE
LONGVIEW RANGE
SKEENA MOUNTAINS
NASS RANGE
MEZIADIN JUNCTION
Moose
N
MORE CREEK
⑦
Moose
Goat
Goat
Goat
Goat
⑥
Goat
ISKUT CANYON
Goat
FORREST KERR DIVERSION
Goat
EDZIZA
MOUNT
PROVINCIAL PARK
SPECTRUM RANGE
KEY MAP
I
0 10 20 30 km
SCALE

B.C. HYDRO

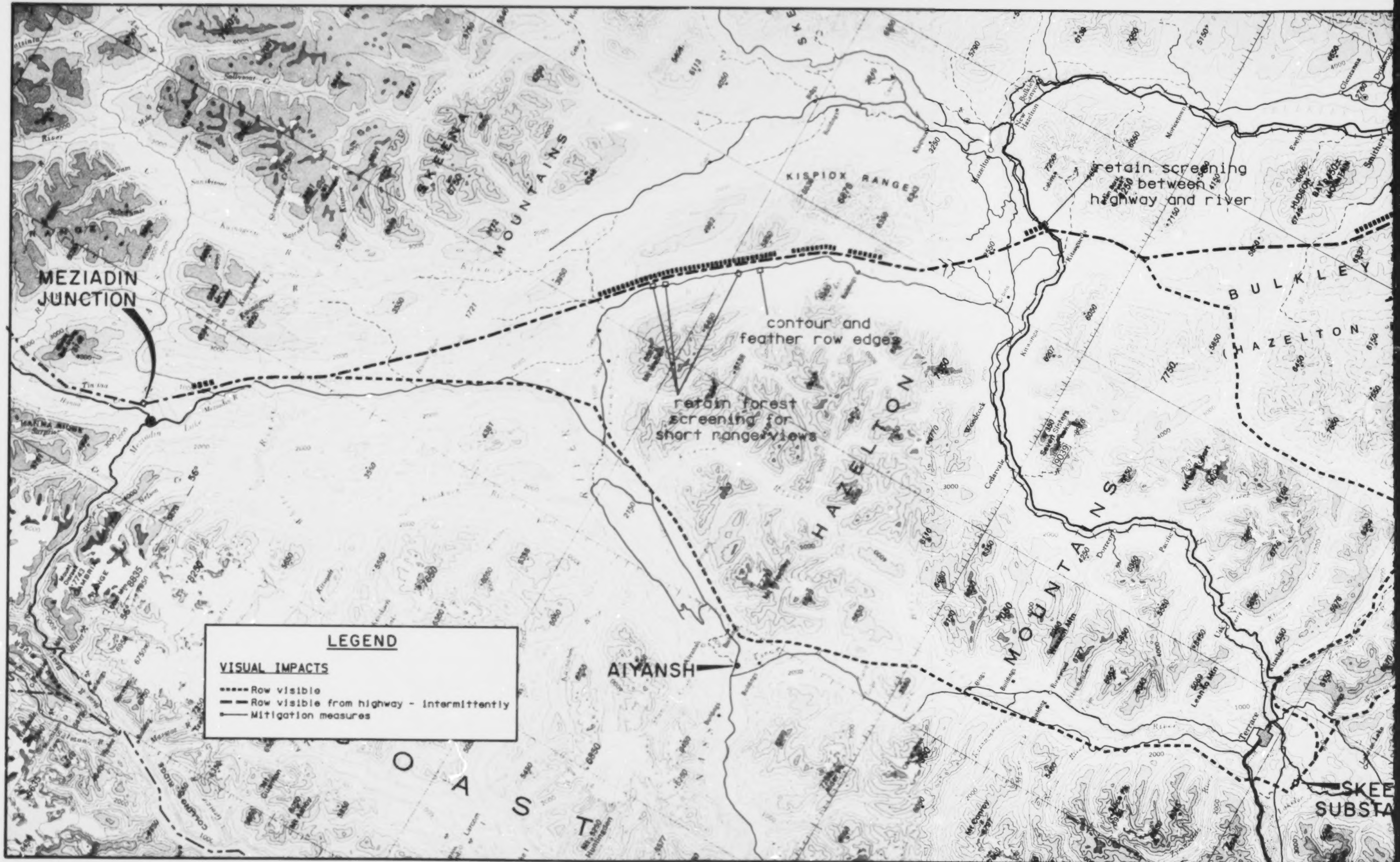
FIGURE 5-6

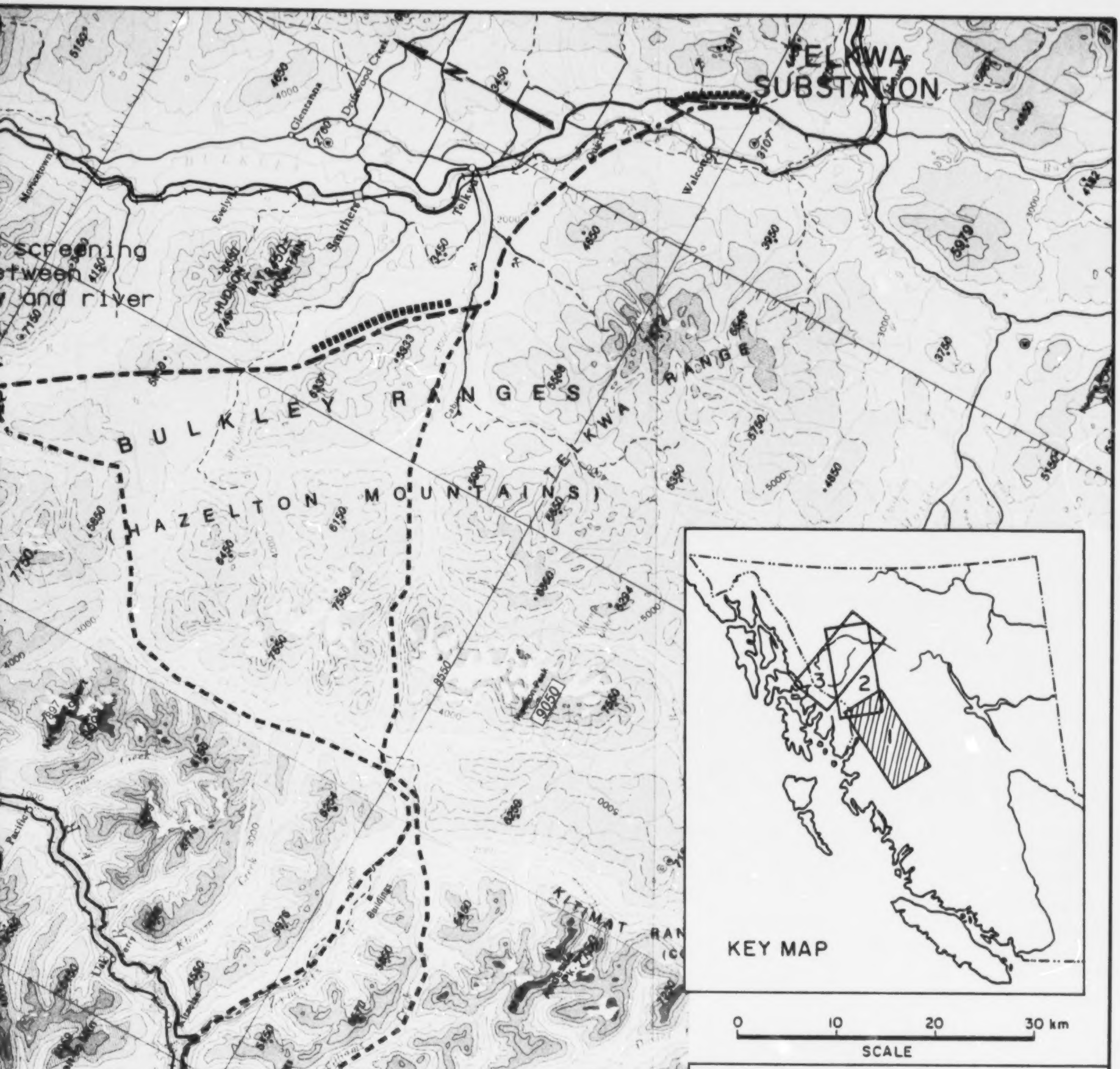
STIKINE-ISKUT DEVELOPMENT INTERIM ASSESSMENT

WILDLIFE RESOURCES ALONG THE TRANSMISSION LINE ROUTE

MAP No. 2

NOVEMBER 1984


MEZIADIN JUNCTION
AIYANSH
SKEENA MOUNTAINS
KISPIOX RANGE
HAZELTON MOUNTAINS
BULKLEY
HAZELTON
COAST
retain screening between highway and river
contour and feather row edges
retain forest screening for short range views
SKEE
SUBSTA
LEGEND
VISUAL IMPACTS
Row visible
Row visible from highway - intermittently
Mitigation measures



TELKWA SUBSTATION
N
Glentanna
Driftwood Creek
Smithers
Telkwa
Walcott
Evelyn
HUDSON BAY MOUNTAIN
screening
between
and river
BULKLEY RANGES
(HAZELTON MOUNTAINS)
TELKWA RANGE
KITIMAT RAN
Terrace
SKEENA SUBSTATION
KEY MAP
1
2
3
0
10
20
30 km
SCALE

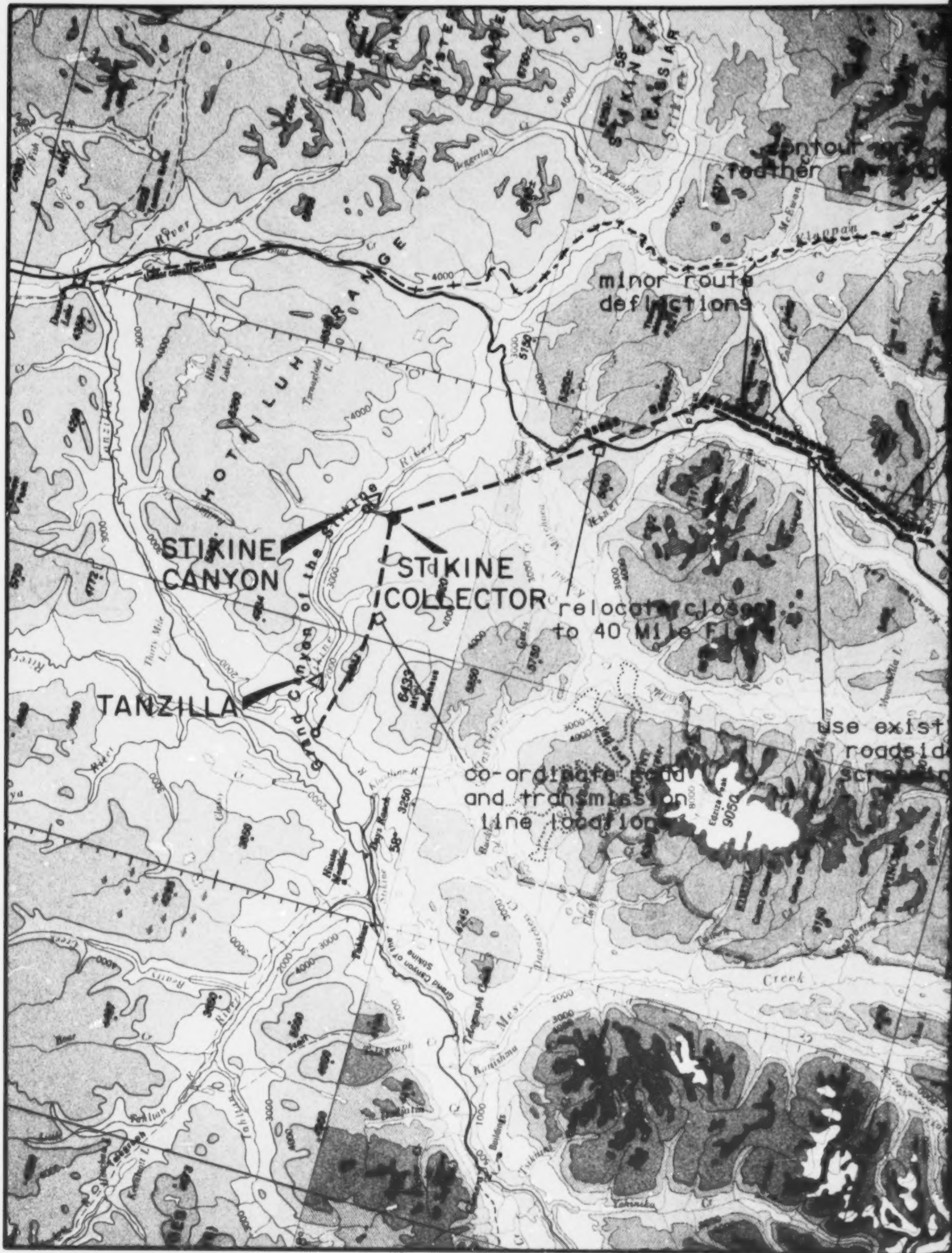
B.C. HYDRO

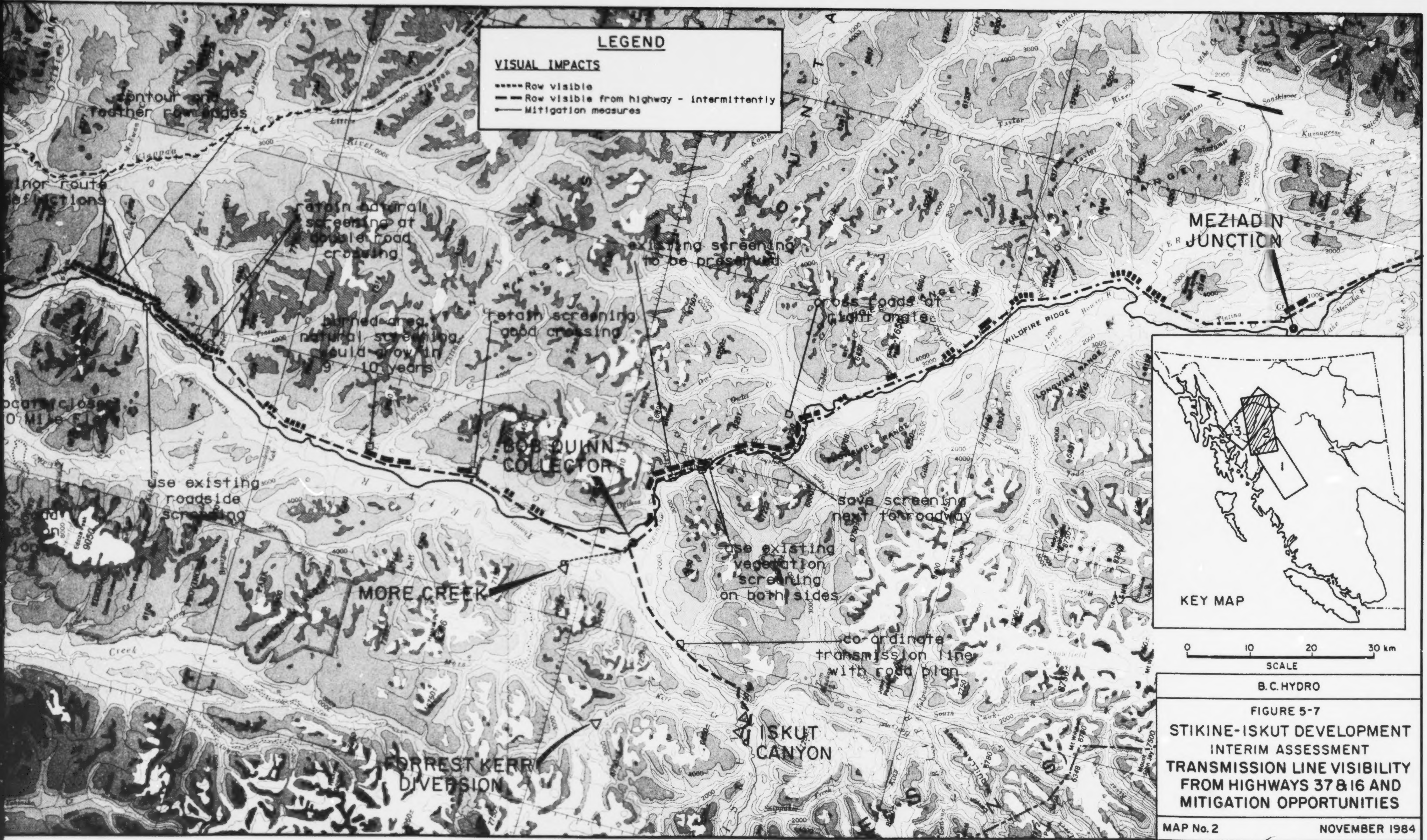
FIGURE 5-7

STIKINE-ISKUT DEVELOPMENT
INTERIM ASSESSMENT

TRANSMISSION LINE VISIBILITY
FROM HIGHWAYS 37 & 16 AND
MITIGATION OPPORTUNITIES

MAP No. 1 NOVEMBER 1984


contour and feather
minor route deflections
HOTAILUH RANGE
STIKINE CANYON
STIKINE COLLECTOR
relocate closer to 40 Mile Flat
Grand Canyon of the Stikine
TANZILLA
co-ordinate road and transmission line locations
use exist roadsid screening
STIKINE RANGES
CASSIAR
Klappan
Creek
9050

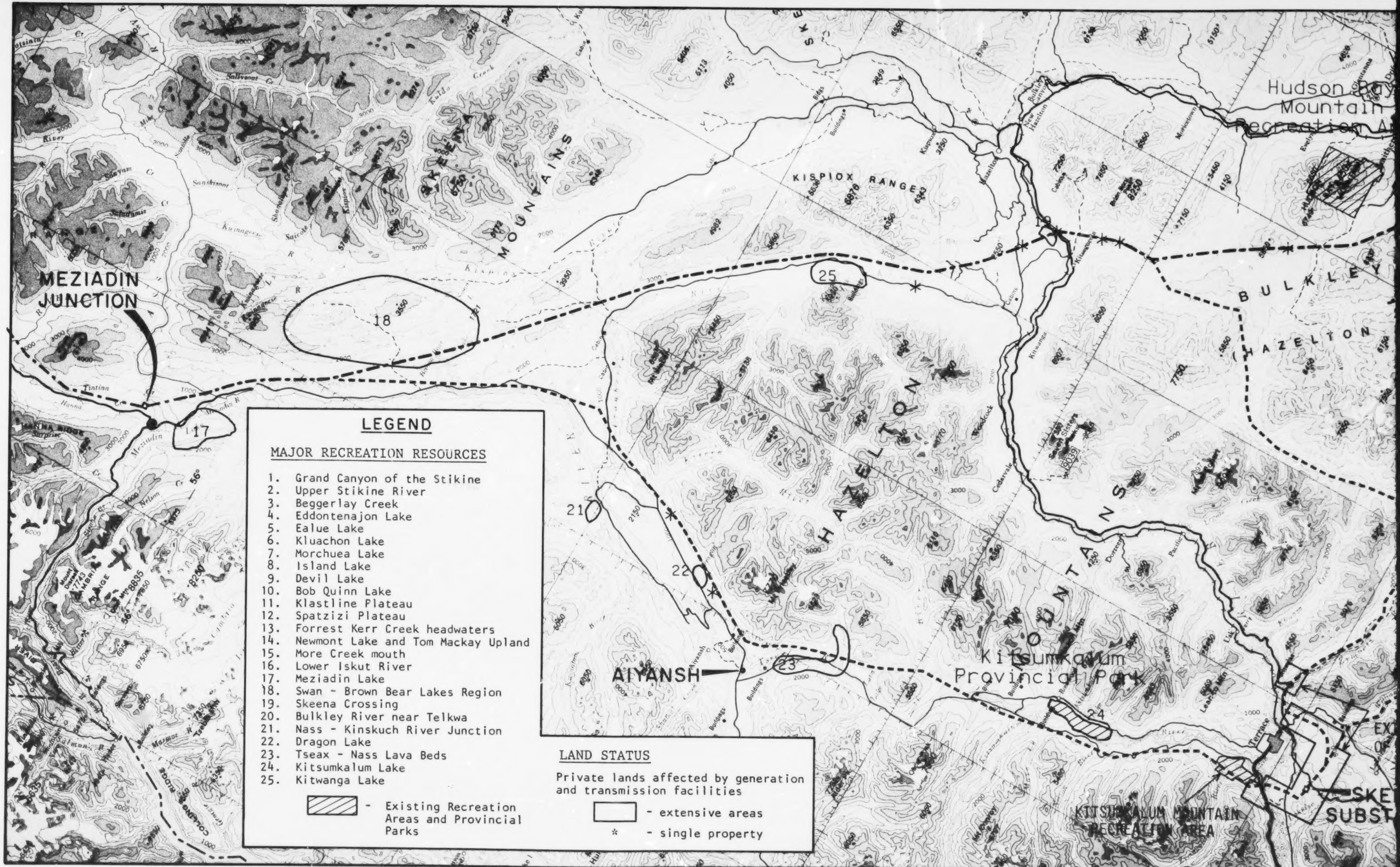

LEGEND
VISUAL IMPACTS
Row visible
Row visible from highway - intermittently
Mitigation measures
contour and feather row edges
inor route deflections
retain natural screening at double road crossing
existing screening to be preserved
burned area, natural screening would grow in 9 - 10 years
retain screening good crossing
cross roads at right angle
MEZIADIN JUNCTION
WILDFIRE RIDGE
ocate closer 0 Mile F
BOB QUINN COLLECTOR
use existing roadside screening
save screening next to roadway
use existing vegetation screening on both sides
MORE CREEK
co-ordinate transmission line with road plan
ISKUT CANYON
FORREST KERR DIVERSION
KEY MAP
1
3
0
10
20
30 km
SCALE

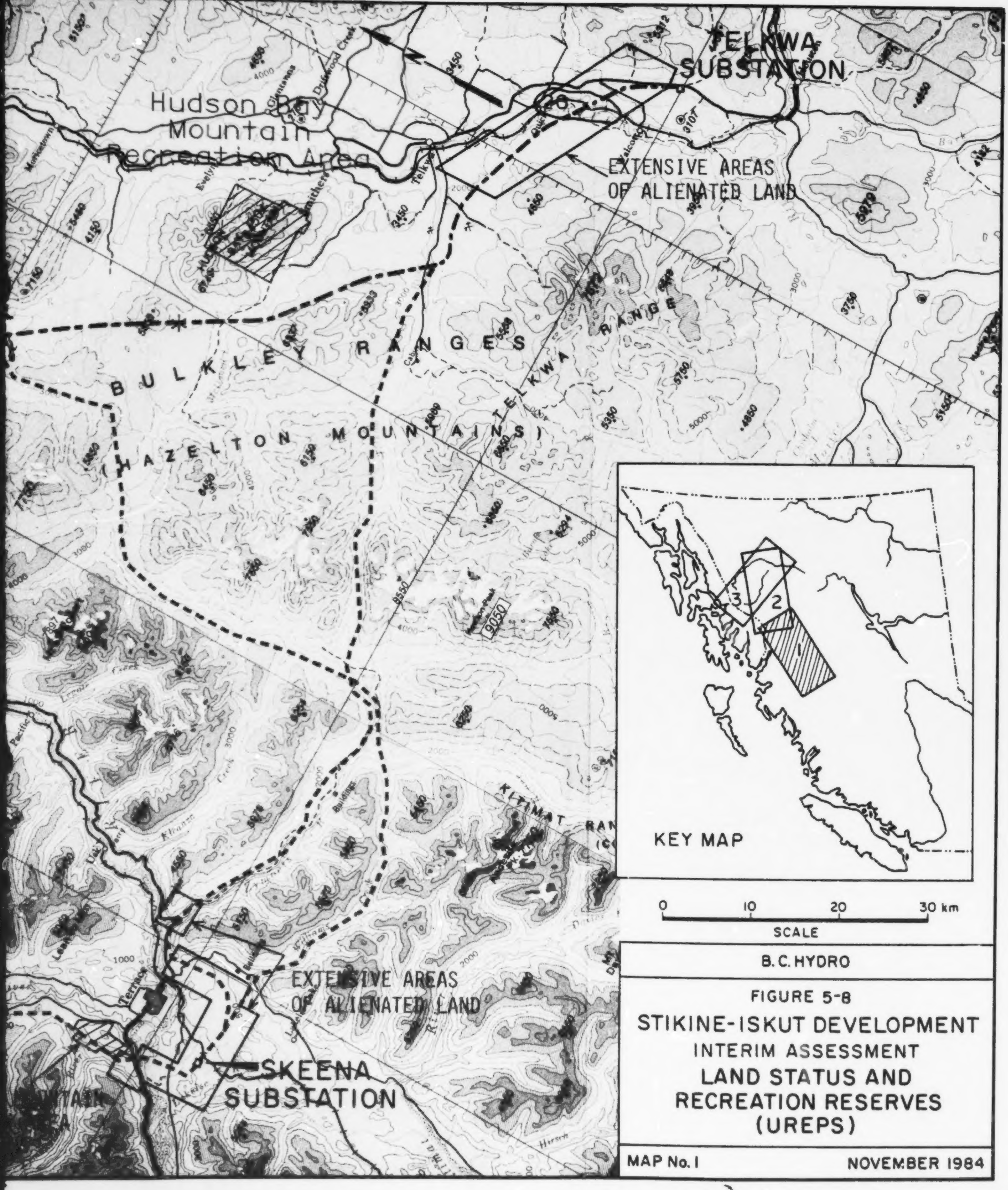
B.C. HYDRO

FIGURE 5-7

STIKINE-ISKUT DEVELOPMENT
INTERIM ASSESSMENT
TRANSMISSION LINE VISIBILITY FROM HIGHWAYS 37 & 16 AND MITIGATION OPPORTUNITIES

MAP No. 2 NOVEMBER 1984


MEZIADIN JUNCTION
AIYANSH
SKEENA MOUNTAINS
KISPIOX RANGES
HAZELTON MOUNTAINS
BULKLEY
HAZELTON
Hudson Bay Mountain Recreation A
Kitsumkalum Provincial Park
KITSUMKALUM MOUNTAIN RECREATION AREA
SKE
SUBST
17
18
21
22
23
24
25
LEGEND
MAJOR RECREATION RESOURCES
1. Grand Canyon of the Stikine
2. Upper Stikine River
3. Beggerlay Creek
4. Eddontenajon Lake
5. Ealue Lake
6. Kluachon Lake
7. Morchuea Lake
8. Island Lake
9. Devil Lake
10. Bob Quinn Lake
11. Klastline Plateau
12. Spatzizi Plateau
13. Forrest Kerr Creek headwaters
14. Newmont Lake and Tom Mackay Upland
15. More Creek mouth
16. Lower Iskut River
17. Meziadin Lake
18. Swan - Brown Bear Lakes Region
19. Skeena Crossing
20. Bulkley River near Telkwa
21. Nass - Kinskuch River Junction
22. Dragon Lake
23. Tseax - Nass Lava Beds
24. Kitsumkalum Lake
25. Kitwanga Lake
▨ - Existing Recreation Areas and Provincial Parks
LAND STATUS
Private lands affected by generation and transmission facilities
☐ - extensive areas
* - single property


TELKWA SUBSTATION
Hudson Bay Mountain Recreation Area
EXTENSIVE AREAS OF ALIENATED LAND
BULKLEY RANGES
TELKWA RANGE
(HAZELTON MOUNTAINS)
KITIMAT RANGES
9050
EXTENSIVE AREAS OF ALIENATED LAND
SKEENA SUBSTATION
KEY MAP
1
2
3
0
10
20
30 km
SCALE

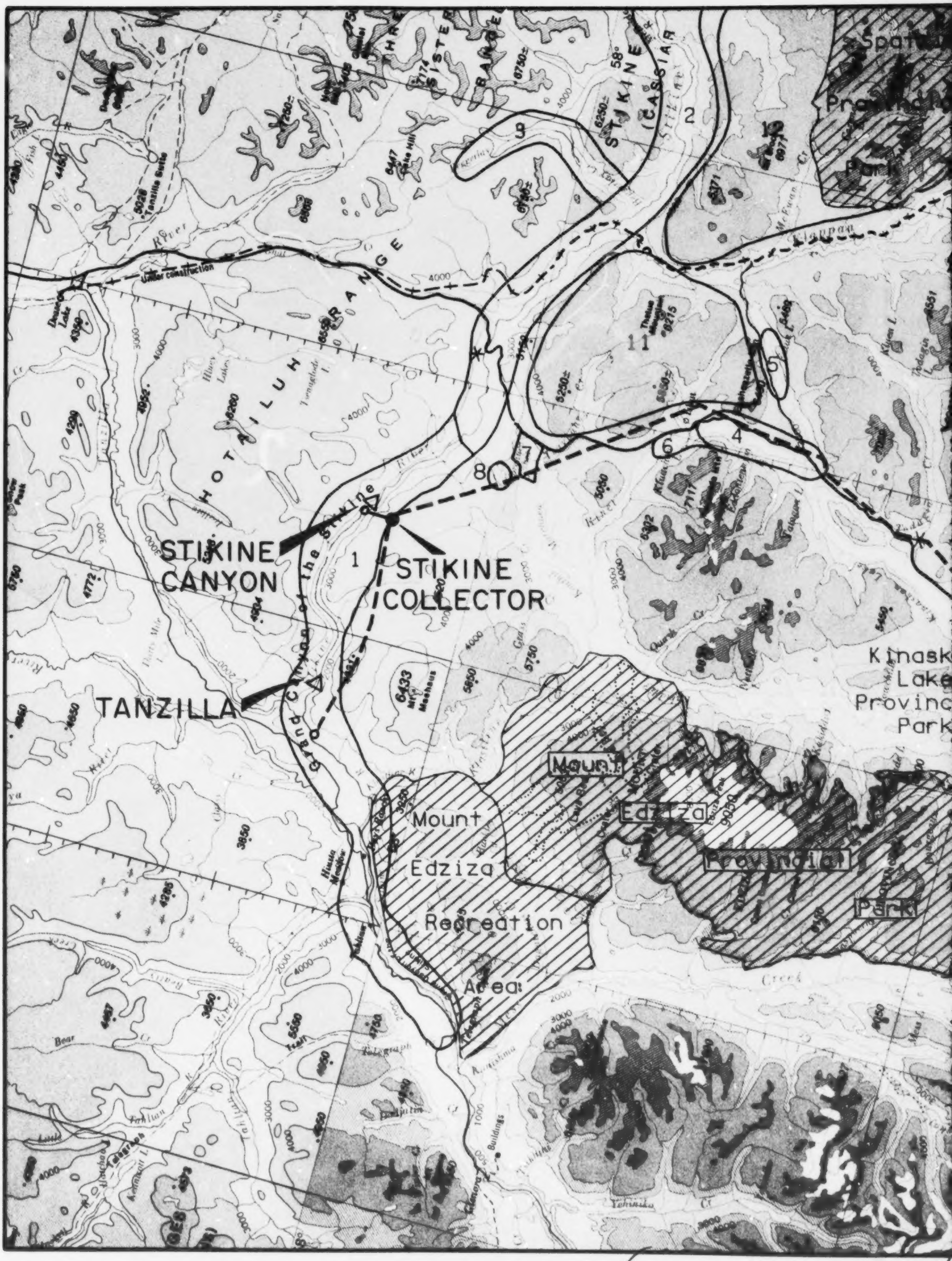
B.C. HYDRO

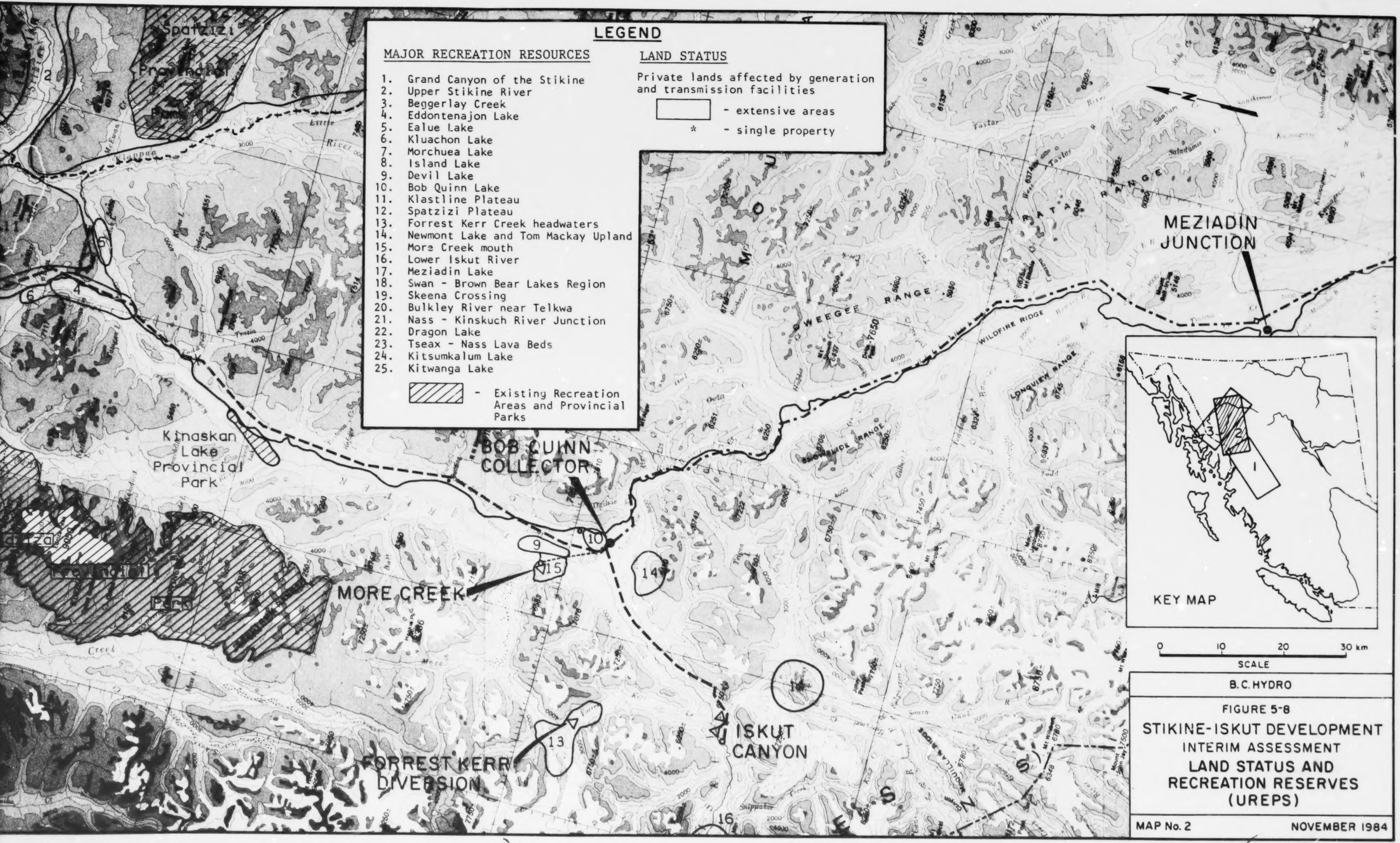
FIGURE 5-8

STIKINE-ISKUT DEVELOPMENT
INTERIM ASSESSMENT
LAND STATUS AND RECREATION RESERVES (UREPS)

MAP No. 1

NOVEMBER 1984

 STIKINE CANYON
STIKINE COLLECTOR
TANZILLA
Grand Canyon of the Stikine
HOTAILUH RANGE
SISTERS RANGE
STIKINE (CASSIAR)
Under construction
Mount Edziza Recreation Area
Mount Edziza Provincial Park
Kinask Lake Provinc Park
Spat
Prov
Park
1
2
4
5
6
7
8
9
11
12
6433
9050


LEGEND
MAJOR RECREATION RESOURCES
1. Grand Canyon of the Stikine
2. Upper Stikine River
3. Beggerlay Creek
4. Eddontenajon Lake
5. Ealue Lake
6. Kluachon Lake
7. Morchuea Lake
8. Island Lake
9. Devil Lake
10. Bob Quinn Lake
11. Klastline Plateau
12. Spatzizi Plateau
13. Forrest Kerr Creek headwaters
14. Newmont Lake and Tom Mackay Upland
15. More Creek mouth
16. Lower Iskut River
17. Meziadin Lake
18. Swan - Brown Bear Lakes Region
19. Skeena Crossing
20. Bulkley River near Telkwa
21. Nass - Kinskuch River Junction
22. Dragon Lake
23. Tseax - Nass Lava Beds
24. Kitsumkalum Lake
25. Kitwanga Lake
▨ - Existing Recreation Areas and Provincial Parks
LAND STATUS
Private lands affected by generation and transmission facilities
☐ - extensive areas
* - single property
Spatsizi Provincial Park
Kinaskan Lake Provincial Park
Provincial Park
BOB QUINN COLLECTOR
MORE CREEK
FORREST KERR DIVERSION
ISKUT CANYON
MEZIADIN JUNCTION
OWEEGEE RANGE
WILDFIRE RIDGE
LONGVIEW RANGE
SNOWSLIDE RANGE
STRATA RANGE
N
KEY MAP
0 10 20 30 km
SCALE
2
4
5
6
9
10
13
14
15
16

B.C. HYDRO

FIGURE 5-8

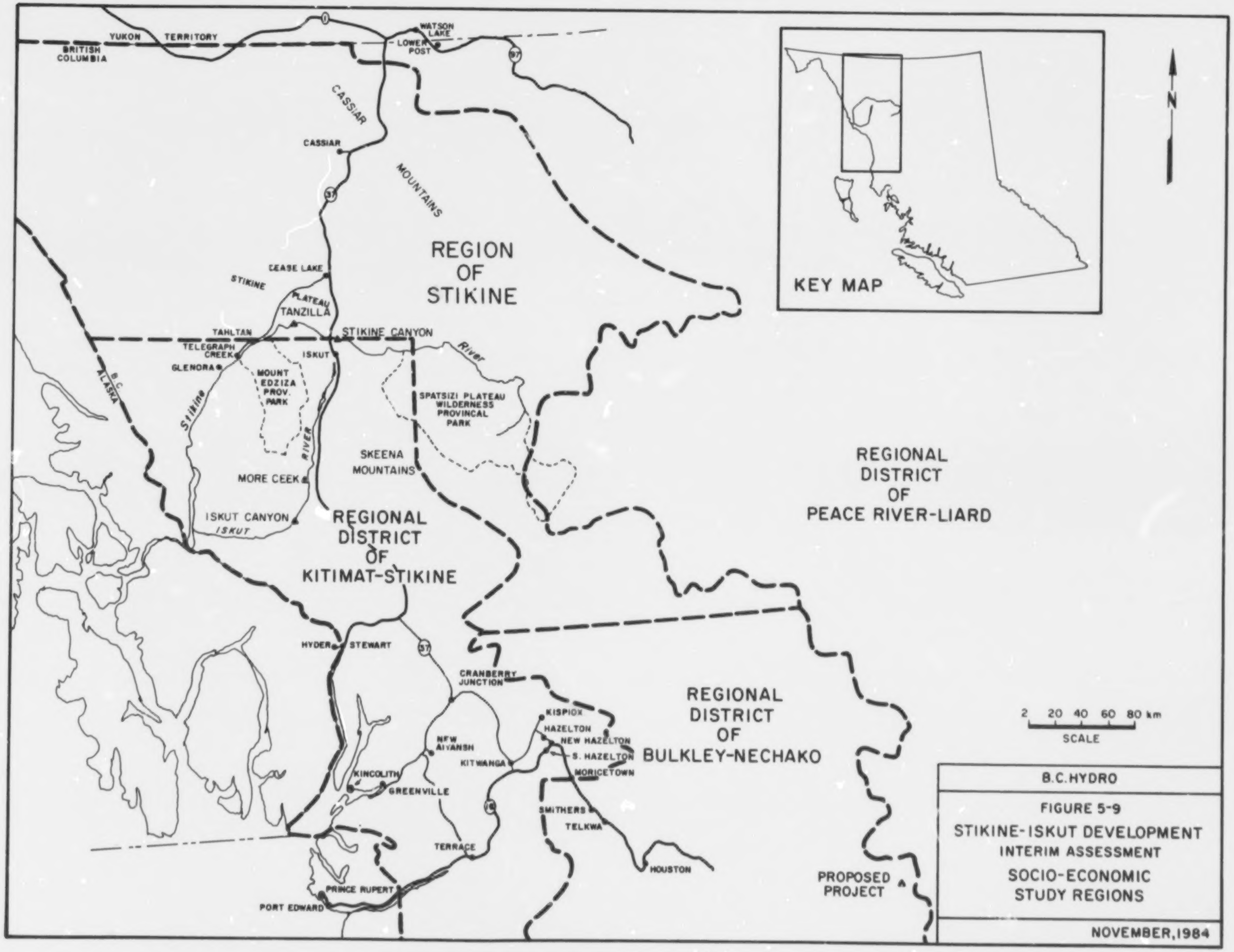
STIKINE-ISKUT DEVELOPMENT

INTERIM ASSESSMENT

LAND STATUS AND RECREATION RESERVES (UREPS)

MAP No. 2

NOVEMBER 1984


YUKON TERRITORY
BRITISH COLUMBIA
WATSON LAKE
LOWER POST
1
97
CASSIAR
CASSIAR
MOUNTAINS
37
REGION OF STIKINE
DEASE LAKE
STIKINE
PLATEAU
TANZILLA
TAHLTAN
STIKINE CANYON
TELEGRAPH CREEK
GLENORA
ISKUT
River
MOUNT EDZIZA PROV. PARK
SPATSIZI PLATEAU WILDERNESS PROVINCAL PARK
B.C.
ALASKA
Stikine
RIVER
SKEENA MOUNTAINS
MORE CEEK
ISKUT CANYON
ISKUT
REGIONAL DISTRICT OF KITIMAT-STIKINE
REGIONAL DISTRICT OF PEACE RIVER-LIARD
HYDER
STEWART
37
CRANBERRY JUNCTION
KISPIOX
HAZELTON
NEW HAZELTON
S. HAZELTON
MORICETOWN
NEW AIYANSH
KITWANGA
KINCOLITH
GREENVILLE
16
SMITHERS
TELKWA
TERRACE
HOUSTON
PRINCE RUPERT
PORT EDWARD
REGIONAL DISTRICT OF BULKLEY-NECHAKO
PROPOSED PROJECT
KEY MAP
N
2 20 40 60 80 km
SCALE

B.C. HYDRO

FIGURE 5-9

STIKINE-ISKUT DEVELOPMENT
INTERIM ASSESSMENT

SOCIO-ECONOMIC
STUDY REGIONS

NOVEMBER, 1984

TABLE 5-1
STIKINE-ISKUT NORMALS - PRECIPITATION SUMMARY

		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Chukachida	No.	3	4	4	4	4	3	4	5	4	4	5	4	
	Mean mm	24.2	16.6	23.1	25.9	37.1	54.4	87.1	60.6	54.9	32.0	15.9	39.2	471.0
Darsmith Creek	No.	1	2	2	3	3	3	3	3	3	3	3	3	
	Mean mm	306.0	118.2	54.0	110.1	84.7	31.8	62.8	143.0	270.2	288.2	184.2	71.8	1724.8
Devils Elbow	No.	2	3	3	3	3	2	3	3	3	3	3	3	
	Mean mm	103.3	50.3	44.3	32.8	18.9	4.7	21.2	33.2	147.0	149.5	103.7	38.0	746.9
Didene	No.	3	3	4	4	4	4	4	5	4	5	5	5	
	Mean mm	16.7	13.9	13.0	16.5	29.4	35.6	59.0	38.4	62.3	51.8	20.8	21.9	379.3
Durham	No.	3	3	3	3	3	2	4	4	1	2	4	2	
	Mean mm	78.8	47.5	33.8	53.1	35.3	31.9	54.3	35.1	201.0	149.8	75.4	40.3	836.3
Eaglenest	No.	4	4	4	4	4	4	4	5	5	5	5	5	
	Mean mm	33.7	23.8	23.9	21.4	38.8	46.6	75.9	50.6	58.4	43.9	22.3	36.6	475.9
Forrest Kerr Glacier	No.	3	3	4	3	3	4	5	5	5	5	3	4	
	Mean mm	125.4	70.7	38.5	70.7	32.7	23.9	44.0	63.1	157.3	195.1	177.5	98.1	1097.0
Forrest Kerr Low	No.	4	4	4	3	4	2	3	4	3	4	5	4	
	Mean mm	130.6	95.0	51.1	82.0	44.9	47.4	59.7	52.3	124.8	178.3	144.8	133.7	1144.6
Frog River	No.	4	4	4	3	4	4	5	4	4	5	5	4	
	Mean mm	47.2	29.0	30.1	51.5	46.3	39.3	89.7	71.0	80.6	67.2	32.4	50.3	634.6
Klappan	No.	3	3	3	3	3	4	4	5	5	4	4	3	
	Mean mm	24.2	16.3	7.7	10.6	25.5	27.7	60.8	27.0	32.9	28.3	18.9	28.8	308.7
Lower Iskut	No.	2	2	3	3	3	3	3	3	2	3	3	3	
	Mean mm	265.3	100.0	90.7	115.0	109.2	56.0	87.3	142.8	171.0	290.5	199.0	99.2	1726.0
McBride River	No.	7	7	6	7	6	7	8	8	8	8	8	7	
	Mean mm	44.1	13.6	15.8	12.7	34.2	44.3	54.6	36.3	46.0	25.2	20.7	40.6	388.1
McBride 5000	No.	4	4	4	4	4	4	5	5	4	5	5	4	
	Mean mm	20.0	21.6	25.8	22.3	42.2	41.1	57.6	51.4	67.2	36.0	22.3	29.8	437.3
Pallen	No.	4	3	4	4	4	3	5	5	3	5	5	4	
	Mean mm	34.4	15.5	27.2	26.4	44.7	65.4	76.5	50.7	72.3	42.6	26.7	19.5	501.9
Pitman	No.	4	4	3	4	4	4	5	4	5	5	3	3	
	Mean mm	31.6	12.6	26.9	23.9	45.4	40.2	82.1	86.1	62.7	42.9	20.1	34.4	508.9
Site Z	No.	2	1	2	1	0	1	1	0	0	2	1	1	
	Mean mm													
Tucho	No.	4	4	4	4	3	4	4	5	5	5	5	4	
	Mean mm	39.8	25.6	32.8	35.7	52.3	53.9	89.6	72.1	67.5	66.7	36.2	31.0	603.2
Tumeka Creek	No.	3	3	3	4	4	4	4	4	5	4	4	3	
	Mean mm	76.8	36.9	21.7	22.6	37.2	43.6	64.6	54.9	83.7	108.1	69.3	48.9	668.3
Upper Stikine	No.	4	4	4	4	4	4	5	5	5	5	5	3	
	Mean mm	40.9	23.9	20.7	33.3	36.6	49.2	74.5	63.2	90.4	68.2	35.7	42.9	579.5
Bob Quinn	No.	6	7	7	7	7	6	6	6	5	6	6	6	
	Mean mm	39.5	36.5	14.4	24.6	25.1	30.3	58.4	47.4	95.6	116.1	59.4	78.4	625.7
Iskut Ranch	No.	8	7	7	7	6	5	7	6	7	8	8	8	
	Mean mm	20.0	11.6	8.4	3.8	19.9	44.2	52.9	50.8	48.7	40.0	19.5	30.5	350.3
Todagin Ranch	No.	11	11	11	9	11	9	10	10	11	11	11	11	
	Mean mm	28.7	13.1	15.5	15.0	20.8	39.1	46.8	41.6	47.8	48.8	29.1	34.2	380.5
Dease Lake	No.	35	35	35	35	35	35	35	35	35	36	36	36	
	Mean mm	27.8	24.6	22.3	12.3	23.1	43.6	55.5	52.5	46.2	35.2	29.3	33.5	405.9
Telegraph Creek	No.	24	24	21	20	18	19	19	18	18	21	21	20	
	Mean mm	36.2	23.9	24.5	17.0	14.9	27.6	19.9	30.4	37.3	47.7	44.8	52.4	376.6

TABLE 5-2

STIKINE-ISKUT NORMALS - TEMPERATURE SUMMARY

		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
McBride 5000 1499 m	No.	4	4	4	4	4	4	5	5	5	5	5	5	
	Max.	-9.2	-5.7	-2.0	2.5	9.4	15.9	16.1	15.0	8.6	2.7	-3.7	-16.1	
	Min.	-16.0	-12.7	-10.8	-6.9	-0.6	3.7	5.1	3.9	0.7	-3.5	-9.5	-16.2	
	X. Max.	5.7	4.7	7.7	14.3	29.9	26.6	28.1	26.7	18.6	13.9	7.4	2.4	
	X. Min.	-36.2	-31.3	-25.4	-20.7	-7.6	-3.9	-1.6	-1.7	-12.1	-16.2	-29.9	-35.3	
Pallen 1494 m	No.	3	2	4	4	4	4	5	5	5	5	5	5	
	Max.	-7.1	-5.2	-3.6	0.1	7.0	12.5	13.8	12.7	6.9	0.5	-5.7	-9.9	
	Min.	-11.6	-10.9	-10.6	-7.7	-1.2	3.1	5.1	4.2	0.3	-4.3	-9.9	-14.5	
	X. Max.	1.7	2.6	6.6	14.1	30.4	22.9	23.9	23.5	18.6	9.2	3.7	-0.5	
	X. Min.	-30.8	-23.7	-26.7	-22.3	-7.8	-2.8	-1.7	-0.6	-12.4	-16.3	-28.6	-31.3	
Pitman 945 m	No.	4	3	4	4	4	3	5	5	5	5	5	5	
	Max.	-12.8	-5.3	-4.8	6.1	13.4	19.5	19.9	18.5	12.3	4.8	-5.2	-13.9	
	Min.	-22.1	-18.1	-16.5	-7.9	-2.0	2.0	4.8	2.7	0.6	-3.6	-13.4	-22.3	
	X. Max.	8.6	5.7	7.9	19.1	30.7	29.1	29.6	30.0	22.1	19.5	9.9	6.9	
	X. Min.	-47.4	-32.8	-36.8	-28.5	-10.0	-4.4	-3.6	-4.3	-7.8	-17.7	-36.3	-45.9	
Site Z 542 m	No.	2	2	2	2	1	2	2	1	1	1	0	0	
	Max.													
	Min.													
	X. Max.													
	X. Min.													
Stikine Canyon 936 m	No.	4	3	3	4	3	3	5	5	5	5	5	5	
	Max.	-9.4	-2.0	2.5	6.4	13.9	17.2	19.1	18.0	12.5	6.1	-2.0	-11.5	
	Min.	-17.7	-12.2	-9.0	-5.1	0.6	4.2	6.2	4.6	1.3	-2.2	-10.0	-19.1	
	X. Max.	6.7	8.1	8.5	19.7	34.7	27.6	28.7	27.7	22.3	15.2	9.2	4.6	
	X. Min.	-38.0	-22.7	-26.4	-20.1	-6.2	-1.7	-1.2	-1.7	-9.6	-16.5	-31.5	-37.6	
Tucho 1265 m	No.	4	4	3	4	4	4	5	5	5	5	5	5	
	Max.	-9.7	-6.0	-1.3	2.8	10.3	16.7	17.4	15.9	10.1	4.5	-3.2	-11.2	
	Min.	-18.5	-15.9	-12.5	-7.6	-1.0	2.6	4.9	3.5	0.5	-2.8	-11.2	-18.9	
	X. Max.	7.8	4.3	6.1	13.6	28.9	26.4	27.8	26.8	21.0	18.7	7.7	3.8	
	X. Min.	-39.7	-33.9	-31.5	-24.5	-10.5	-3.4	-2.3	-2.9	-13.5	-16.6	-33.9	-39.7	
Tumeka Creek 1295 m	No.	4	4	3	4	4	4	5	5	5	4	5	5	
	Max.	-8.8	-5.3	-1.5	2.0	8.5	14.2	15.1	14.7	8.9	3.3	-3.0	-9.4	
	Min.	-17.1	-12.3	-10.2	-6.7	-1.3	1.7	4.2	3.1	0.4	-2.7	-8.4	-15.4	
	X. Max.	2.1	4.4	8.1	13.6	27.3	24.5	26.0	26.4	20.3	13.9	8.6	2.[illegible]	
	X. Min.	-37.9	-29.4	-26.6	-20.3	-10.4	-3.8	-2.6	-2.5	-11.9	-13.2	-26.4	-35.[illegible]	
Upper Stikine 1393 m	No.	4	4	4	4	4	3	5	5	5	5	5	5	
	Max.	-8.5	-5.0	-2.3	1.6	8.3	13.0	15.1	14.3	8.4	2.7	-3.0	-9.5	
	Min.	-15.9	-13.0	-12.3	-7.8	-1.2	1.8	4.5	3.4	0.8	-3.0	-9.6	-16.7	
	X. Max.	9.7	4.0	8.5	14.3	25.9	23.1	25.2	26.1	19.9	15.5	9.3	4.5	
	X. Min.	-35.9	-30.0	-28.9	-24.1	-8.8	-4.1	-2.8	-2.7	-11.9	-16.0	-28.7	-37.2	
Bub Quinn 457 m	No.	6	7	7	7	7	6	6	6	5	6	6	6	
	Max.	-5.6	-2.2	4.7	8.9	14.3	18.8	20.0	19.6	13.9	7.9	-0.3	-8.4	
	Min.	-13.4	-10.3	-5.6	-2.7	1.4	5.5	7.8	7.1	4.3	0.9	-6.0	-15.7	
	X. Max.	8.5	7.0	13.5	21.5	30.0	30.5	32.0	30.5	22.0	17.0	8.5	5.0	
	X. Min.	-35.0	-35.5	-22.0	-14.0	-5.5	-1.5	0.0	0.5	-4.5	-6.5	-30.0	-36.0	
Iskut Ranch 869 m	No.	8	8	8	7	7	5	7	6	7	8	8	8	
	Max.	-7.1	-2.2	3.1	7.2	13.1	17.7	19.4	18.6	13.3	7.3	-0.4	-8.4	
	Min.	-17.8	-13.2	-9.3	-6.0	-0.5	2.6	5.0	4.3	1.0	-2.0	-10.5	-19.5	
	X. Max.	10.0	8.9	12.0	20.0	34.0	27.0	34.0	31.1	23.3	17.0	9.5	7.0	
	X. Min.	-42.0	-35.5	-29.4	-23.0	-10.0	-4.0	-3.0	-5.0	-13.0	-17.0	-36.7	-42.8	
Todagin Ranch 899 m	No.	11	11	11	9	11	9	10	10	11	11	11	11	
	Max.	-9.0	-3.7	2.0	7.0	12.4	17.0	18.6	18.6	13.0	5.9	-3.1	-9.0	
	Min.	-19.8	-16.5	-12.2	-6.2	-1.8	1.9	4.5	3.9	0.6	-2.7	-12.7	-19.0	
	X. Max.	5.0	7.8	12.5	20.5	34.0	27.0	29.0	31.7	27.2	17.2	9.0	7.8	
	X. Min.	-46.1	-45.0	-39.4	-24.0	-9.0	-4.0	-3.3	-5.0	-10.0	-12.8	-38.3	-45.6	
Dease Lake 816 m	No.	12	12	13	13	13	13	13	13	13	12	12	13	
	Max.	-15.0	-7.1	-0.8	6.5	12.9	17.5	19.4	18.2	13.0	5.8	-4.1	-11.6	
	Min.	-24.4	-18.6	-14.0	-6.0	-0.9	3.3	5.7	5.0	1.3	-3.3	-12.8	-20.4	
	X. Max.	8.9	11.7	12.8	22.2	31.7	33.9	31.7	32.2	28.9	20.6	14.4	7.2	
	X. Min.	-51.1	-48.3	-42.8	-31.7	-11.1	-5.6	-2.2	-6.1	-15.0	-23.3	-38.9	-46.1	
Telegraph Creek 163 m	No.	22	26	22	21	19	21	20	21	22	22	19	21	
	Max.	-14.4	-3.9	3.3	11.5	16.7	20.9	22.5	22.0	15.9	8.8	-2.0	-9.7	
	Min.	-22.0	-14.4	-9.1	-2.6	1.6	6.2	8.6	8.0	4.0	-0.5	-8.1	-16.6	
	X. Max.	7.8	9.4	15.0	24.5	30.0	35.0	33.3	36.0	29.4	21.7	11.1	8.3	
	X. Min.	-41.7	-38.9	-29.4	-18.3	-5.0	-1.1	2.2	0.0	-7.2	-16.7	-30.6	-40.0	

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		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Chukachida 1083 m	No.	3	4	4	3	4	3	5	5	5	4	5	4	
	Max.	-7.6	-4.7	0.5	4.6	11.2	15.6	17.9	17.4	11.9	5.2	-3.0	-13.1	
	Min.	-19.4	-19.0	-16.3	-9.0	-2.6	0.9	8.8	0.7	-0.2	-4.6	-13.8	-23.0	
	X. Max.	8.2	6.2	10.4	17.6	29.3	24.9	28.4	28.6	23.6	17.2	8.9	4.8	
	X. Min.	-47.2	-41.1	-39.4	-30.6	-11.4	-5.9	-4.7	-5.9	-12.1	-21.6	-31.5	-43.7	
Darsmith 27 m	No.	2	2	2	2	3	3	3	3	3	3	3	3	
	Max.	-8.0	-2.3	4.3	8.6	15.1	19.7	20.6	18.5	14.2	8.0	-0.5	-6.9	
	Min.	-12.5	-8.6	-6.0	-2.1	2.7	6.3	6.8	6.4	4.8	2.0	-4.6	-11.7	
	X. Max.	4.3	5.7	10.8	19.2	26.4	30.0	28.9	26.6	21.3	14.3	10.4	4.2	
	X. Min.	-31.5	-29.7	-17.6	-8.9	-3.4	-0.3	1.9	1.1	-3.3	-5.0	-20.3	-25.1	
Dawson 1037 m	No.	3	4	4	4	4	4	5	5	5	5	5	4	
	Max.	-6.6	-3.9	1.4	5.5	10.2	17.5	18.7	18.3	12.5	6.1	-3.5	-13.2	
	Min.	-18.7	-18.7	-15.6	-8.0	-2.7	0.8	3.3	1.4	-0.6	-4.6	-11.2	-24.4	
	X. Max.	6.4	7.1	10.1	17.6	30.7	27.1	29.5	28.5	24.6	17.9	9.7	5.5	
	X. Min.	-46.3	-39.9	-37.9	-27.9	-12.3	-5.5	-4.5	-5.3	-10.8	-19.3	-40.4	-45.5	
Devils Elbow 125 m	No.	2	3	2	3	3	3	3	3	2	3	3	3	
	Max.	-10.5	-4.2	4.2	8.8	12.9	20.2	21.4	20.1	15.0	8.3	-1.8	-8.9	
	Min.	-15.9	-8.7	-6.3	-1.4	4.2	8.4	10.6	9.6	5.9	2.7	-5.5	-14.0	
	X. Max.	3.9	4.4	10.3	20.8	20.5	31.6	32.5	27.3	20.8	15.7	9.2	5.2	
	X. Min.	-34.2	-30.3	-18.7	-10.3	-2.7	1.0	4.4	3.8	-3.3	-6.2	-23.2	-30.6	
Didene 1343 m	No.	3	4	3	3	4	4	5	5	5	5	5	4	
	Max.	-7.2	-7.2	-1.9	-0.6	7.9	14.1	15.7	14.9	9.3	2.7	-3.3	-10.4	
	Min.	-13.7	-14.4	-12.8	-5.5	-2.0	1.2	3.2	1.6	-0.7	-4.2	-11.1	-18.1	
	X. Max.	2.9	3.3	5.7	8.4	27.1	23.1	26.1	25.7	21.0	14.8	10.1	2.8	
	X. Min.	-35.6	-33.6	-29.0	-26.6	-12.4	-4.5	-3.8	-6.1	-14.8	-19.2	-29.0	-41.0	
Durham 1143 m	No.	3	3	3	3	3	3	3	4	3	4	3	3	
	Max.	-7.6	-4.0	-0.6	1.5	8.5	14.2	15.1	15.2	9.1	3.7	-2.5	-7.5	
	Min.	-15.0	-6.9	-9.1	-6.0	-1.0	2.3	4.8	4.6	1.8	-1.6	-8.0	-14.4	
	X. Max.	6.3	5.1	8.2	8.4	16.4	24.0	26.3	24.6	18.0	13.0	6.9	4.8	
	X. Min.	-32.4	-26.8	-25.1	-20.1	-8.7	-3.2	-1.0	-2.2	-4.6	-11.6	-27.2	-33.0	
Eaglenest 1525 m	No.	4	4	4	4	4	4	5	5	5	5	5	5	
	Max.	-8.5	-5.1	-2.2	1.3	8.2	14.1	14.9	14.0	8.7	2.4	-2.4	-8.2	
	Min.	-14.0	-11.0	-9.3	-6.4	-0.1	3.7	5.4	4.7	1.3	-2.9	-7.6	-13.7	
	X. Max.	5.2	4.7	7.7	14.8	28.9	24.6	25.8	25.5	19.8	13.4	9.2	3.0	
	X. Min.	-32.2	-30.0	-21.7	-19.3	-7.7	-3.7	-1.1	-0.8	-11.0	-13.9	-28.3	-35.1	
Forrest Kerr Glacier 1144 m	No.	3	4	4	2	4	4	5	5	5	5	5	4	
	Max.	-9.5	-6.2	-2.3	1.0	5.5	9.1	10.4	12.2	7.4	2.1	-2.0	-7.9	
	Min.	-15.3	-11.3	-8.6	-5.6	0.1	3.7	5.4	5.4	2.7	-1.7	-6.4	-12.6	
	X. Max.	3.4	3.6	9.4	12.2	18.2	17.6	17.0	29.9	16.0	10.7	7.8	3.9	
	X. Min.	-29.9	-28.3	-20.2	-14.1	-9.7	-1.6	0.6	-0.1	-6.3	-10.9	-24.8	-31.0	
Forest Kerr Low 595 m	No.	4	3	4	4	4	4	4	4	4	5	5	4	
	Max.	-6.9	-2.6	2.3	5.9	12.2	18.6	17.7	17.0	12.6	5.9	-1.2	-9.5	
	Min.	-14.2	-12.8	-9.7	-4.1	-0.4	4.1	4.7	3.2	1.9	-0.9	-7.6	-17.2	
	X. Max.	4.9	5.7	7.7	16.4	27.0	28.0	25.2	25.8	20.4	13.3	6.9	2.3	
	X. Min.	-39.7	-31.9	-26.8	-21.3	-7.9	-4.0	-1.8	-2.3	-7.0	-9.8	-29.1	-39.0	
Frog River 1519 m	No.	2	3	4	4	4	3	4	4	5	5	5	5	
	Max.	-9.1	-4.0	-3.4	0.9	8.3	13.1	14.2	14.1	8.2	2.0	-3.4	-9.0	
	Min.	-15.9	-11.1	-11.8	-7.7	-0.7	3.0	4.7	4.2	0.7	-3.6	-9.2	-16.0	
	X. Max.	2.7	3.0	5.2	13.3	25.3	22.7	25.6	25.2	20.4	14.0	6.1	-2.6	
	X. Min.	-36.5	-26.4	-29.2	-22.9	-8.7	-3.8	-0.5	-1.2	-12.2	-15.9	-31.8	-33.5	
Klappan 884 m	No.	2	3	3	3	3	4	5	5	5	5	4	4	
	Max.	-2.3	-1.4	2.7	6.7	14.0	17.4	18.2	17.6	11.9	5.8	-3.3	-10.7	
	Min.	-11.3	-12.5	-10.9	-4.6	0.0	3.1	5.7	3.9	0.9	-2.4	-12.1	-19.6	
	X. Max.	-0.1	6.5	10.9	20.0	32.3	26.7	28.7	28.2	23.0	16.5	10.2	4.5	
	X. Min.	-35.2	-30.4	-34.7	-21.3	-8.2	-4.4	-1.9	-4.0	-9.6	-13.8	-34.8	-42.2	
Lower Iskut 20 m	No.	2	2	2	3	3	3	3	3	3	3	3	3	
	Max.	-7.7	-3.2	5.0	8.5	14.7	18.4	19.5	17.4	13.2	8.0	0.5	-7.3	
	Min.	-13.0	-10.0	-3.4	-1.0	3.4	7.1	8.7	8.2	6.3	3.1	-3.3	-12.5	
	X. Max.	3.7	2.7	10.8	17.1	24.3	27.3	28.4	26.7	19.2	14.0	9.9	3.4	
	X. Min.	-35.4	-30.0	-21.8	-10.5	-1.8	-0.9	3.8	2.8	-2.2	-4.3	-21.7	-31.2	
McBride River 774 m	No.	7	7	7	7	6	6	7	6	7	8	8	7	
	Max.	-12.3	-4.5	2.1	7.9	13.2	17.3	19.8	19.2	13.9	5.0	-4.4	-13.1	
	Min.	-21.7	-17.8	-12.9	-5.8	-1.0	3.4	6.4	5.1	1.2	-3.0	-12.7	-20.9	
	X. Max.	6.5	8.9	10.8	21.1	34.0	28.1	30.5	32.2	23.9	18.9	9.9	3.5	
	X. Min.	-46.7	-42.8	-37.8	-24.6	-11.6	-3.3	-1.7	-1.8	-7.9	-14.1	-38.3	-48.9	

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TABLE 5-3

VEGETATION TYPES IN AREAS OF PROJECT RESERVOIRS*[1]

	Tanzilla Project (ha)	Stikine Canyon Project (ha)	More Creek (ha)	Iskut Canyon (ha)
Riparian edge		145	374	149
Alluvial cottonwood forest		45		
Alluvial white spruce forest		670		
Mixed alluvial forest		1989		
Bog birch shrubland		239		
Black spruce bog		90		
Mixed upland forest		715		
Trembling aspen-white spruce forest	37	124		
Trembling aspen forest	293	1065		
Black and white spruce forest		1397		
White spruce and lodgepole pine forest		367		
Lodgepole pine forest		1055		
White spruce (trembling aspen) forest	104	55		
White spruce-subalpine fir forest	33	353		
Burned, mainly herbaceous regrowth (1969)	72			
Subalpine forest		63		
Dry slopes	27	137		
Mountain avens			199	222
Sedge meadow			125	
Cottonwood forest			869	188
Cottonwood-sitka spruce forest			458	220
Subalpine fir-cottonwood			14	70
Alder slide			288	
Subalpine fir forest			682	28
Western hemlock forest				238
Sitka spruce-western hemlock forest			141	812
Lodgepole pine-paper birch western hemlock				268
Subalpine parkland			5	
Steepslope complex			105	22
Bare ground		624	31	296
Rock	203	250		13
Lake			11	
Burned, mixed regrowth (Prior to 1940)				120
TOTAL (ha)	769	9383	3302	2646

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*[1] Data from Talisman, 1984.

TABLE 5-4

TRANSMISSION LINE IMPACTS ON VEGETATION ZONES AND ASSOCIATIONS IN STUDY AREAS 2 AND 3

Zones and Associations		Hectares of Right-of-Way Study Area 2	Study Area 3
Alpine Tundra Zone			
Salix - Petasites nivalis Association		-	28
	Sub-total	-	28
Spruce-Willow-Birch Zone			
Spruce-Willow-Birch Asociation		89	-
Spruce-Willow-Birch/Mesic Festuca altaica Association		119	-
Stunted Aspen/Cottonwood-Grassland Association		3	-
	Sub-total	211	-
Engelmann Spruce-Subalpine Fir Zone			
Subalpine Fir - Vaccinium membranaceum - Rubus petatus - Pleurozium schreberi - Barbiophozia lycopodiodes Association		124	24
Subalpine Fir - Vaccinium membranaceum - Rubus petatus - Pleurozium schreberi - Barbiophozia lycopodiodes/Subalpine Fir - Oplopanax horridus Association		-	322
	Sub-total	124	346

TABLE 5-4 - (Cont'd)

		Study Area 2	Study Area 3
Interior Cedar-Hemlock Zone			
Zonal Hemlock - Moss Association		11	477
Zonal Hemlock-Moss/Dry Hemlock - Moss Association		-	15
Dry Hemlock - Moss Association		11	8
Zonal Hemlock/Devils Club - Oak Fern - Feather Moss Association		562	1380
Devils Club - Oak Fern - Feather Moss Association		-	195
Devils Club - Oak Fern - Feather Moss/ Devils Club - Fern - Leafy Moss Association		-	1607
Spruce - Pine - Shrub Seral Association		-	226
Spruce-Pine-Shrub Seral/Devils Club - Fern - Leafy Moss Association		-	15
Spruce - Pine - Shrub Seral/Aspen - Birch - Red Osier Dogwood Seral Association		-	365
Aspen - Birch - Red osier Dogwood Seral Association		-	167
	Sub-total	584	4455
Boreal White and Black Spruce Zone			
Mixed White Spruce/Aspen - Forb Association		725	-
White Spruce - Moss Association		56	-
White Spruce - Moss/Mesic Festuca altaica Association		73	-
Grasslands/Scrub Association		47	-
Mixed White Spruce/Aspen - Forb/Black Spruce - Labrador Tea - Horsetail Association		90	-
	Sub-total	991	-

TABLE 5-4 - (Cont'd)

		Study Area 2	Study Area 3
Sub-boreal Spruce Zone			
Mesic Rose - Peavine - Moss/Moist Shrub - Forb Association		-	373
Mesic Rose - Peavine - Moss/Oak Fern Association		-	201
Moist - Shrub - Forb Association		-	76
Devils Club -Oak Fern - Feather Moss/Oak Fern Association		-	15
Moist Thimbleberry - Forb Association		-	8
	Sub-total	-	673
Inter-zonal			
Alluvial Spruce/Cottonwood Association		2	82
Black Spruce Bog Association		5	-
Fen (open and shrub) Associations		19	172
Fen (open and shrub)/Alluvial Spruce/ Cottonwood Association		-	21
Fire Areas		478	90
Logged Areas		-	437
Avalanche Tracks		-	8
Lava Bed Areas		20	-
Cultural		-	29
	Sub-total	524	839
	Grand Total	2434	6341

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*[1] Based on right-of-way widths:
1 x 230 kV T/L 30 m
2 x 500 kV T/L 120 m
3 x 500 kV T/L 170 m

TABLE 5-5

FOREST COVER CLASSIFICATION IN AREA OF PROPOSED RESERVOIR*[1]

Item	Proposed Reservoir					
	Tanzilla	Stikine Canyon	Forest-Kerr	Iskut	More Creek	Total
	(Area in Hectares)					
A. Forest Land						
1. Mature Forest						
Coniferous	89	4 526	23	1 605	1 369	7 612
Deciduous	8	1 634	-	376	937	2 955
Total Mature	97	6 160	23	1 981	2 306	10 567
2. Immature Forest						
Coniferous	16	2 158	-	201	102	2 477
Deciduous	58	366	-	16	71	511
Total Immature	74	2 524	-	217	173	2 988
3. Not Satisfactorily Restocked	77	-	-	-	-	77
4. Noncommercial Cover	-	213	-	10	117	340
5. Total Forest Land	248	8 897	23	2 208	2 596	13 972
B. Nonforest Land	652	3 803	117	1 792	1 644	8 008
C. Total Reservoir	900	12 700	140	4 000	4 240	21 980

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*[1] Table reproduced from: Forestry Report Stikine-Iskut Environmental Studies. Forestal International Ltd., 1980.

TABLE 5-6

TIMBER VOLUMES BY SPECIES AND RESERVOIR*[1]

Species	Reservoir					
	Tanzilla	Stikine Canyon	Forest-Kerr	Iskut	More Creek	Total
	(Volume in m^3 Close Utilization 18 cm + dbh to 10 cm top)					
Hemlock			200	537 400	187 800	725 400
Balsam	1 500	28 400	4 700	60 500	256 600	351 700
Spruce	14 600	647 400	1 300	185 300	141 300	990 000
Pine	600	209 200	200	16 800	2 300	229 000
Total Coniferous	16 700	885 000	6 400	800 000	588 000	2 296 100
Cottonwood	200	27 300		67 700	157 700	252 900
Birch		5 000		800	3 700	9 500
Aspen	2 000	174 000	—	15 200	11 700	202 900
Total Deciduous	2 200	206 300	—	83 700	173 100	465 300
TOTAL	18 900	1 091 300	6 400	883 700	761 100	2 761 400

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*[1] Table reproduced from: Forestry Report Stikine-Iskut Environmental Studies. Forestal International Ltd., 1980.

TABLE 5-7

IMPACTS OF THE PROPOSED PROJECT ON THE NET MERCHANTABLE FOREST LANDS OF THE CASSIAR TIMBER SUPPLY AREA AND ISKUT TIMBER SUPPLY BLOCK

	Cassiar TSA	Iskut TSB
Net Merchantable Forest Area (ha)	119 076	72 299
Forest Land Within Proposed Reservoirs (ha)	13 972	13 972
Percent of Forest Land Base	11.7	19.3
Forest Land Within T/L ROW (ha)	2 700	2 700
Percent of Forest Land Base	2.3	3.7
Total Percent Impacts on the Net Merchantable Forest Area	14.0	23.0

TABLE 5-8

WATER QUALITY OF STIKINE AND ISKUT RIVERS

Parameter	Units	Station No. 008C08CF0002 Stikine River above Choquette River		Station No. 008C08CG0001 Iskut River below Johnson River		Station No. 15024800 (USGS) Stikine River near Wrangell Alaska		Station No. 0920085 Stikine River at Telegraph Creek	
		Maximum	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum
Temperature	°C	11.5	0.0	10.0	0.0	11.0	0.0	16.7	0
pH (F&L)	-	8.3	7.0	8.3	6.8	8.7	7.1	8.4	7.4
Specific Conductance (F&L)	µS/cm	223	94.6	272	93.5	240	81	232	76
Turbidity	NTU	340	0.4	360	0.4	270	0.2	240	0.4
Colour	-	130	5.0	140	5	15	5	60	<5.0
Alkalinity Total	mg/L $CaCO_3$	93.5	40.8	98.2	41.3	100	41.7	101	23.7
Hardness Total	mg/L $CaCO_3$	111.0	44.1	127	53.5	113	38	111	35.9
Calcium Dissolved	mg/L	31.2	14.7	38.8	16.8	32.2	13	29.4	11.1
Magnesium Dissolved	mg/L	8.4	1.8	7.6	1.9	8.3	1.3	-	-
Potassium Dissolved	mg/L	1.8	0.8	1.7	0.7	1.9	0.6	0.9	0.4
Sodium Dissolved	mg/L	4.6	1.0	7.4	1.1	6.4	0.8	4.9	1.1
Chloride Dissolved	mg/L	2.4	0.4	4.0	0.2	9.7	0.2	1.2	0.1
Fluoride Dissolved	mg/L	0.88	0.04	0.99	0.04	0.2	0.04	0.15	<0.05
Silica Reactive	mg/L	8.1	2.6	6.8	2.1	10	0.6	9.6	4.4
Sulphate Dissolved	mg/L	17.2	5.7	34.5	8.3	25	2.2	23.9	5.6
Nitrogen Nitrate/Nitrite	mg/L	0.20	0.03	0.300	0.021	0.44	0.3	0.1	<0.001
Residue Nonfilterable	mg/L	688	1	1170	1	380	1	141	24
Residue Filterable	mg/L	145	61	161	54	131	69	141	77
Residue Fixed Nonfilterable	mg/L	670	1	1138	1	380	1	133	20
Residue Fixed Filterable	mg/L	132	14	142	30	116	65	127	13
Arsenic Extractable	mg/L	0.0034	0.0003	0.0048	0.0002	0.0008*	0.0001*	-	-
Selenium Extractable	mg/L	0.0004	0.0001	0.0007	0.0001	0.0004*	0.0003*	-	-
Cadmium Extractable	mg/L	0.0020	0.0005	0.0008	0.0005	0.0005*	0.0005*	-	-
Copper Extractable	mg/L	0.0600	0.001	0.07	0.002	0.0005*	0.0005*	<0.01*	0.003*
Zinc Extractable	mg/L	0.0600	0.001	0.06	0.001	0.022*	0.001*	0.05*	<0.001*
Iron Extractable	mg/L	11.00	0.10	20	0.88	45	0.1	1.3*	0.018
Lead Extractable	mg/L	0.030	0.001	0.009	0.001	0.003	0.001	<0.01*	<0.001*
Manganese Extractable	mg/L	0.45	0.01	1.00	0.01	0.22	0.01	0.22*	<0.01*
Mercury Extractable	µg/L	0.09	0.05	0.12	0.05	0.05	0.05	-	-
Nitrogen Total Dissolved	mg/L	0.357	0.04	0.432	0.031	0.193	0.069	-	-
Phosphorus Total	mg/L	1.142	0.008	1.7	0.037	0.466	0.009	0.016	<0.002
Total Inorganic Carbon	mg/L	26.1	10.0	28.1	11.0	25.7	10.0	-	-
Total Organic Carbon	mg/L	10.0	0.92	11.0	1.4	6.4	0.9	-	-

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* Total rather than extractable values.

(F&L) Field and Laboratory

Sources

- Ministry of Environment, Province of British Columbia
- Water Quality Branch, Inland Waters Directorate, Pacific and Yukon Region, Environment Canada
- U.S. Geological Survey

Comment

For a number of parameters, single extremely high values (outliers) were disregarded and not included in the table. The reasons for making this judgement were mainly: lack of information relating to sampling, handling and analytical techniques; overall paucity of data over presented timeframe; and numerous other areas of uncertainty. The presented data should be guardedly reviewed as the exactness of maximum and minimum values is uncertain.

TABLE 5-9

COMMON AND SCIENTIFIC NAMES OF FISH AND SHELLFISH

Common Name	Species
Pink Salmon	Oncorhynchus gorbuscha
Chum Salmon	Oncorhynchus keta
Coho Salmon	Oncorhynchus kisutch
Sockeye Salmon	Oncorhynchus nerka
Chinook Salmon	Oncorhynchus tshawytscha
Cutthroat Trout	Salmo clarki
Rainbow Trout	Salmo gairdneri
Dolly Varden	Salvelinus malma
Eulachon	Thaleichthys pacificus
Starry Flounder	Platichthys stellatus
Dungeness Crab	Cancer magister
King Crab	Paralithodes camtschatica
Tanner Crab	Chionoecetes bairdi
Pink Shrimp	Pandalus borealus
Humpback Shrimp	Pandalus hypsinotus
Sidestripe Shrimp	Pandalopsis dispar
Spot Shrimp (Prawn)	Pandolus platyceros
Surf Clam	Spisula alaskana
Butter Clam	Saxidomus gigantia
Littleneck Clam	Protothaca staminea

TABLE 5-10

BRITISH COLUMBIA BIG GAME SPECIES REGIONAL ESTIMATES - MARCH 1978, AND AVERAGE ESTIMATED ANIMAL HARVEST IN STUDY AREA

Wildlife Species	Estimated Population in Region 6*[1]	% of Provincial Population	Estimated Number of Animals Harvested in Management Units*[2] Traversed by Corridor and Proposed Reservoirs	% of Harvest or Area in Relation to Region 6	% of Harvest or Area in Relation to Province
Moose	80 000	33	608	28.8	4.9
Mountain Goat	24 000	52	93	42.9	19.6
Caribou	9 500	40	50	37.3	18.5
Mule Deer	80 000	17	47	2.9	0.2
Thinhorn Sheep	4 000	40	19	38.8	9.1
Grizzly Bear	3 300	41	14	40.0	9.4
Black Bear	14 000	24	148	43.3	6.0
Area	274 299 km²	28.1%	98 964 km²	36.1%	10.1%

*[1] From Erickson (1983). Region 6 comprises Management Units 6-1 to 6-29.

*[2] Data from 1976 to 1979, resident hunter harvest only, Management Units 6-9, 15, 16, 17, 19, 20, 21, 22.

N.B. Study area includes Areas 1, 2, and 3, i.e. downstream, generation and transmission areas in British Columbia.

TABLE 5-11

SUMMARY OF APPROXIMATE RELATIVE IMPACTS ON WILDLIFE OF PROPOSED ISKUT-STIKINE PROJECTS

Factors Impacted	Iskut Projects		Stikine Projects	
	Area (km^2)	Portion of Total Reservoir Areas	Area (km^2)	Portion of Total Reservoir Areas
Reservoir Flooding				
Habitat flooded	59.5	35%	111.7	65%
	Number	Impact Ratio*[3]	Number	Impact Ratio*[3]
Population Reductions				
- moose (winter)	15	0.4	80*	1.3*
- goat	0	0	55	1.5**
- black bear	15	1.0	34	1.0
- grizzly bear	7	2.1**	3	0.4
- terrestrial furbearers*[1]	100	0.8	266*	1.1
- waterfowl pairs	20	0.7	60±*	1.1
- golden eagle pairs	0	0	1 - 2	-
- grouse	600	0.9	1 400*	1.1
- songbirds (pairs)	20 000	1.0	36 000*	1.0
Others*[2]				
Habitat diversity	2		3	
New access	3		1.5	
Blockage of movement	1		2.5	
Noise and disturbance	1.5		2.5	
Deer/sheep	0		1.5	

* Impacts will be primarily in the Stikine Canyon reservoir.

** Impact ratio indicates the presence of greater than expected populations in a given reservoir.

*[1] Marten, fisher, fox, coyote, lynx and wolverine.

*[2] 0 = nil; 1 = low; 2 = moderate; 3 = high impact expected.

*[3] Impact Ratio = $\frac{\text{population in reservoir/populations in all reservoirs}}{\text{project area/all reservoir areas}}$

Example for waterfowl pairs in Iskut reservoirs: $\frac{(20/80)}{0.35} = \frac{0.25}{0.35} = 0.7$

A ratio of 1 or less indicates that a species is found in expected numbers, or less, given the size of the reservoir. Ratios significantly greater than 1 indicate the presence of greater than expected wildlife populations within the reservoir. No impact ratio (-) is calculated when the number of animals is very low.

Source: Adapted from Blood and Anweiler, 1982b.

TABLE 5-12

SUMMARY OF WILDLIFE IMPACTS ALONG THE PROPOSED CORRIDOR OF THE STIKINE/ISKUT TRANSMISSION PROJECT

Project Action	Impacts on Wildlife	Extent*[a]	Duration*[b]	Rating a x b	Negative or Positive
A. Pre-development Surveys					
1. Activities by crew, aircrafts, etc.	Disturbance for most wildlife species during critical seasons.	2	1	2	-
2. Field camps, clearing of survey line	Habitat loss from vegetation clearing.	1	2	2	-
B. Right-of-way					
1. Clearing right-of-way, camp areas, etc.	Habitat loss from clearing of vegetation and/or interruption of migration movements for most wildlife species.	2	4	8	-
2. Human activity	Wildlife disturbance and possible harassment.	2	1	2	-
	Disruption of fur-bearer trapping and big game guiding activities.	2	1	2	-
3. Garbage disposal	Attracting of bears and other scavengers; man-bear conflicts.	2	1	2	-
4. Maintenance	Wildlife disturbance.	2	4	4*[c]	-
	Forage production for some species.	2	3 to 4*[d]	6 to 8	+
C. Access Road					
1. Construction and maintenance	Wildlife disturbance and habitat exclusion.	2	1 and 4	2 and 8	-
	Habitat loss and barrier to wildlife movements.	1	4	4	-
2. Traffic	Wildlife disturbance.	2	4	8	-
	Direct mortality.	2	4	8	-
3. Increased access	Direct wildlife mortality due to increased hunting, poaching and trapping in new areas.	2 to 4	4	8 to 16	-
	Increased opportunities for recreational hunters and trappers, with associated revenues.	2 to 4	2	4 to 8	+
	Disruption of trapping and game guiding	1	4	4	-

TABLE 5-12 - (Cont'd)

Project Action	Impacts on Wildlife	Extent*[a]	Duration*[b]	Rating a x b	Negative or Positive
D. Construction: Placement of Towers and Stringing					
1. Human activity	Wildlife disturbance and exclusion.	1	1	1	-
2. Construction of tower footings	Habitat loss and reduced soil productivity due to compaction and/or mixing of topsoil and mineral soil.	1	1	1	-
3. Transportation of construction materials and crew	Increased wildlife/vehicle collisions.	2	1	2	-

*[a] Extent: 4 - provincial, 3 - regional, 2 - local (up to 50 km away), 1 - site-specific; (up to 1 km from disturbance).

*[b] Duration: 4 - long-term >50 years, 3 - 10 to 50 years, 2 - up to 10 years, 1 - only during construction period.

*[c] This was given a lower rating, as level of activity will be low and intermittent.

*[d] Duration, and benefits, will depend on vegetation maintenance practices adopted.

TABLE 5-13

VISUAL RESOURCES
SCENIC DISTINCTION SCORES
STIKINE RIVER

	Visual Units		
	Klappan	Upper Stikine	Grand Canyon
With Project	38	39	63
Without Project	43	38	89
Change ±	-5	+1	-26

TABLE 5-14

SUMMARY OF UNIQUENESS QUOTIENTS FOR SELECTED RIVER CANYONS IN NORTH AMERICA

	Stikine	Liard	S. Nahanni	Peace	Fraser	Thompson	Coppermine	Lang	St. John	Missinabe	Niagara	Snake	Colorado
Physical Factor Totals	1.95	1.39	1.58	1.06	1.75	2.20	1.50	2.16	1.47	1.86	2.00	1.89	1.14
Appearance Factor Totals	1.19	1.99	1.19	1.83	1.20	1.23	1.62	1.53	1.46	1.46	1.63	1.23	1.47
Human Interest Factor Totals	1.50	0.97	0.64	1.14	0.91	0.72	0.64	0.64	0.89	1.33	1.25	1.16	1.16
Total Uniqueness Quotient	4.64	4.35	3.41	4.03	3.86	4.15	3.76	4.33	3.82	4.65	4.88	4.28	3.77

TABLE 5-15

LENGTH AND PROPORTION OF TRANSMISSION RIGHT-OF-WAY VISIBLE FROM HIGHWAY 37 - AREA 2

Transmission Segment	Right-of-way Length (km)	Scenic Distinction*[1] (High, Medium, Low)	Right-of-way Visible (km)	(%)
Tanzilla to Stikine Collector				
km 0 - km 24	24	M	*[2]	*[2]
Stikine Canyon to Stikine Collector				
km 0 - km 3	3	H	*[2]	*[2]
Stikine Collector to Bob Quinn Collector				
km 0 - km 37	37	H	8	22
km 37 - km 88	51	H/M	30	59
km 88 - km 139	51	M	21	41
More Creek to Bob Quinn Collector				
km 0 - km 11	11	M	2	18
Iskut Canyon to Bob Quinn Collector				
km 0 - km 39	39	M	*[2]	*[2]
TOTAL	216		61	28

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*[1] Life-Space Designs Ltd., 1981.

*[2] Depending on their relative positions the transmission lines may be visible in these areas from the permanent access roads.

TABLE 5-16

LENGTH AND PROPORTION OF RIGHT-OF-WAY VISIBLE FROM HIGHWAYS 16 AND 37
AREA 3

Transmission Segment	New Right-of-way (km)	Scenic Distinction*[1] (High, Medium, Low)	Visible (km)	Visible (%)
km 0 - km 48	48	H	25	52
km 48 - km 96	48	M	10	21
km 96 - km 130	34	L	5	15
km 130 - km 181	51	L	3	5
km 181 - km 232	51	H/M	28	55
km 232 - km 285	53	H/M	10	19
km 285 - km 338	53	M	-	-
km 338 - km 373	35	M	5	14
TOTAL - Area 3	373		86	23

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*[1] Scenic distinction as defined in the Preliminary Environmental and Social Impact Assessment of the Stikine-Iskut Transmission System.

TABLE 5-17

SUMMARY OF PREHISTORIC HERITAGE RESOURCES; STIKINE-ISKUT GENERATION (RESERVOIR)

Site No.	Type/Function	Relative Size	Level of Significance	Features/Artifacts
IaTl 2	Butchering Site	Small	Moderate	- hearth features - burnt bone - fire broken rock - obsidian detritus
IaTl 3	Camp	Small	Low	- hearth feature - fire broken rock - displaced bone
IaTm 1	Camp/Game Procurement and Butchering	Medium	High	- multicomponent deposits - caribou crossing - faunal remains
IaTm 3	Camp	Small	Medium	- obsidian detritus - faunal remains - look-out

Note: All sites are located in the area affected by the Stikine Canyon dam and reservoir.

TABLE 5-18

SUMMARY OF HISTORIC HERITAGE RESOURCES;
STIKINE-ISKUT GENERATION (RESERVOIR)

Site No.	Age	Site Type/Function	Associated Features	Significance
IaTl 1	late historic	- log cabin - trapping	- tools and implements - garbage pits	low
IaTl 4	late historic	- possible camp for Jewish family	- wooden frames for tents and/or cabin	moderate
HlTh 1	late historic	- log cabin remains - trapping	- historic trail - trap set	low
IaTk 1	late historic	- campsite	- bed frames(?) - log table - hearth - tree cache	low
HlTk 1	late historic	- log cabin - camp - trapping	- possible animal (dog) shelters	low
HkTj 1	late historic	- artifact location - camp	- dogsled - shell casings - hearth	low
HkTj 2	late historic	- campsite - hunting	- moose bones - tent frame - log feature	low
HkTj 3	early historic	- native burial ground	- picket fence - wooden cross - stone cairns - Hyland Post Trail	high
HkTj 4	early historic	- hunting/guiding - campsite	- hearths - tent poles - notched trees - Hyland Post Trail	medium
HkTj 5	late historic	- campsite - hunting/trapping	- tree cache - hearth - table supports - drying frame - metal smoker	low
HkTj 6	late historic	- log cabin - camp/residence	- log foundation	medium
IaTm 1*[1]	late historic	- campsite - hunting	- cut wooden poles - tree cache - prehistoric remains	medium

Note: *[1] This site has prehistoric artifacts as well.

All sites are located in the area affected by the Stikine Canyon dam and reservoir.

TABLE 5-19

SUMMARY OF HERITAGE RESOURCES; STIKINE-ISKUT PROJECT-GENERATION ANCILLARY DEVELOPMENT AND MATERIALS EXPLORATION AREAS

Site No.	Site Type/Function	Historic	Pre-historic	Associated Features	Significance Level	Development Area
IaTn 1	- isolated find		X	- obsidian artifacts	low	Ancillary Development
IaTq 3	- isolated find		X	- natural depression	low	Tanzilla Area 14
IaTq 6	- lithic scatter - probably associated with hunting		X	- lithic detritus	medium	Tanzilla Area 14
IaTq 7	- lithic scatter		X	- lithic detritus - obsidian core	medium	Tanzilla Area 14
IaTq 8	- lithic scatter		X	- lithic detritus	low	Tanzilla Area 14
IaTq 9	- isolated find		X	- obsidian flake	low	Tanzilla Area 14
IaTq 10	- lithic scatter - buried deposits		X	- lithic detritus - historic remains on surface	medium	Tanzilla Area 14
IaTq 11	- isolated find		X	- obsidian flake	low	Tanzilla Area 14
IaTq 12	- lithic scatter		X	- lithic detritus	low	Tanzilla Area 14
IaTq 14	- isolated find		X	- obsidian flake	low	Tanzilla Area 14
IaTq 15	- lithic scatter		X	- obsidian detritus	low	Tanzilla Area 14
IaTq 16	- food cache	X		- elevated tree cache	low	Tanzilla Area 14
IaTq 17	- isolated find		X	- obsidian flake	low	Tanzilla Area 14
HlTm 6	- log cabin site - native hunting camp	X X		- log cabin - small wooden shed - dog shelters - trail - garbage pit - various historic artifacts	medium	Morchuea Lake Area B-1
HlTm 1	- Small hearth		X	- burned bone - hammerstone - fire broken rock	low (disturbe)	Morchuea Lake Area B
HlTm 4	- Lithic Scatter - Hunting camp	X	X	- obsidian flakes and fragments - bone fragments - tent frame - hearth	low (disturbed)	Morchuea Lake Area B

TABLE 5-20

SUMMARY OF LAND IMPACTS

GENERATION FACILITIES

Item	Stikine Canyon	Tanzilla	Iskut Canyon	More Creek	Total
Reservoir Area					
Crown Land (ha)	12 589	850	3 700	4 300	21 439
Private Land (ha)	11	0	0	0	11
No. of Private Properties	1	0	0	0	1
Affected Interests on Crown Land (Number and Type)					
Reserves	11	0	0	0	11
Timber Sale Licence	1	0	0	0	1
Traplines	5	3	1	2	9
Guiding Territories	4	2	3	1	7
Forest Service Recreation Site	1	0	0	0	1
Ecological Reserve Application	1	1	1	0	2
Mineral Claims	1	0	0	0	1
Grazing Permits	1	0	0	0	1
Airport Landing Strip	1	0	0	0	1
Indian Burial Site	1	0	0	0	1
Total Number of Affected Interests	27	6	5	3	35

TRANSMISSION FACILITIES

	Area 1	Area 2	Area 3	Total
Land Area (ha)	-	2 434	6 341	8 775
No. of Private Properties	-	2	5 plus undetermined no. in Telkwa Substation areas	
Affected Interests on Crown Land	n/a	n/a	n/a	

TABLE 5-21
CONSTRUCTION MANPOWER ESTIMATES - GENERATION

Calendar Year No.	Stikine Canyon		Tanzilla		Iskut Canyon		More Creek	
	Average	Peak	Average	Peak	Average	Peak	Average	Peak
1	450	750	850	1350	300	500	150	220
2	800	1200	1250	1900	550	850	200	300
3	900	1300	1400	2050	800	1200	250	400
4	1050	1500	1750	2500	20	1200	50	500
5	1200	1750	2000	2950	750	1100	300	400
6	1200	1750	1950	2850	300	450	30	100
7	950	1300	1350	1900				
8	600	800	650	950				
9	50	150	50	150				

Note:

1. Manpower estimates are based on project arrangement and construction schedules presented in Report No. 1163 "Stikine-Iskut Hydroelectric Development, Feasibility Study, March 1980" by the Hydroelectric Generation Project Division of B.C. Hydro.

2. Calendar years shown are relative to the initial construction date, which is different for each project.

TABLE 5-22
MANPOWER ESTIMATES - TRANSMISSION CONSTRUCTION

Calendar Year No.	Average	Peak
1	75	75
2	210	240
3	345	440
4	495	620
5	510	635
		Operation
6	400	530
7	295	390
8	130	150
9	50	65
10	25	25

Note: Transmission Manpower estimates assume Year 6 - Iskut Inservice, Year 8 - Stikine Canyon Inservice and Year 10 - Tanzilla Inservice.

BIBLIOGRAPHY

Anweiler, G.G. and D.A. Blood. 1982. An overview impact assessment of proposed Stikine-Iskut access and exploration programs on wildlife. Draft consultant report prepared by Donald A. Blood and Associates for B.C. Hydro, Vancouver, February 1982.

(AEL 1982a). Aquatic Environments Limited. 1982. Fish populations associated with proposed hydroelectric dams on the Stikine and Iskut rivers, Vol. I Baseline study, Vol. II Preliminary Assessment of Potential Impacts, Vol. III Support Documents. Unpublished preliminary consultant report prepared for B.C. Hydro.

(AEL 1982b). Aquatic Environments Limited. 1982. Tahltan Fry Enumeration Study. Unpublished preliminary consultant report to B.C. Hydro.

(AEL 1983a) Aquatic Environments Limited. 1983. Late winter survey. Sockeye salmon spawning habitat. Stikine River, 1983. Unpublished preliminary consultant report prepared for B.C. Hydro.

(AEL 1983b) Aquatic Environments Limited. Studies of Salmon Spawning in the Stikine River 1982. Unpublished preliminary consultant report to B.C. Hydro.

(AEL 1984) Aquatic Environments Limited. 1984. "Continued Monitoring and Selected Studies of Salmon Populations in the Canadian Segment of the Stikine River Drainage, 1983." Unpublished preliminary consultant report to B.C. Hydro.

Aresco Ltd. 1980. Preliminary Archaeological Study of the Proposed Stikine-Iskut Hydroelectric Development. Published preliminary consultant report to B.C. Hydro.

Aresco Ltd. 1982a. Stikine-Iskut Ancillary Developments. Heritage Resource Overview. Draft consultant report to B.C. Hydro.

Aresco Ltd. 1982b. Stikine-Iskut Hydroelectric Project, Heritage Resource Impact Assessment, 1980/81. Unpublished preliminary consultant report to B.C. Hydro.

Aresco Ltd. 1983. Heritage Resource Inventory, Construction Materials Exploration Areas and Selected Ancillary Facilities, Stikine-Iskut Development. Unpublished preliminary consultant report repared for B.C. Hydro.

Barrett, G.E. 1979. Changes in the discharge of selected rivers in British Columbia during the period of instrumental record. Unpubl. B.Sc. Thesis, Department of Geography, University of British Columbia, Vancouver, B.C. 141 pp.

Beak Consultants Limited. 1981. Preliminary analysis of the potential impact of hydroelectric development of the Stikine River system on biological resources of the Stikine estuary. Published preliminary consultant report prepared for B.C. Hydro.

Beak Consultants Limited. 1982. Analyses of the potential impacts of hydroelectric development of the Stikine River system in Alaska. Unpublished preliminary consultant report prepared for B.C. Hydro.

Bengeyfield, W. 1979. A background study of available knowledge the lower Stikine River and estuary, Alaska. Prepared by Schultz International Ltd., Vancouver, for B.C. Hydro, Vancouver, March 1979.

Bergmann, W. 1978. Salmon spawning populations of the Stikine River. Alaska Department of Fish and Game. Juneau, Alaska.

Blishen, Bernard R., Lockhart, A., Craib, P., Lockhart, E. 1979. "Socio-economic Impact Model for Northern Development", Vol. 2, Department of Indian and Northern Affairs, Government of Canada.

Blood, D.A. 1981. Preliminary Overview of Potential Wildlife Impacts, Proposed Winter 1981/82 Materials Exploration Program. Draft consultant report prepared for B.C. Hydro, Vancouver, by Donald A. Blood and Associates. November 1981.

Blood, D.A. 1982a. Stikine-Iskut moose studies. Draft consultant report prepared for B.C. Hydro, Vancouver, by Donald A. Blood and Associates.

Blood, D.A. 1982b. Potential impacts of Stikine-Iskut hydroelectric projects on bears. Unpublished preliminary consultant report prepared for B.C. Hydro, Vancouver, by Donald A. Blood and Associates. 62 pp. (June 1982).

Blood, D.A. and G.G. Anweiler. 1982a. Stikine-Iskut hydroelectric projects, supplementary wildlife studies. Unpublished preliminary consultant report to B.C. Hydro, Vancouver, B.C. June 1982.

Blood, D.A. and G.G. Anweiler. 1982b. A preliminary evaluation of potential impacts of Stikine-Iskut hydroelectric developments on wildlife. Unpublished preliminary consultant report prepared for B.C. Hydro, Vancouver, by Donald A. Blood and Associates. 198 pp.

Blood, D.A. and M.J. Chutter. 1981. Potential impact of temporary land access to Site Z on wildlife. Draft consultant report to B.C. Hydro, Vancouver, B.C.

Blower, D. 1982. Iskut River (104B) and Spatsizi (104H) ungulate biophysical maps. B.C. Ministry of Environment, Terrestrial Studies Branch, Victoria, B.C.

B.C. Fish and Wildlife. n.d. Resident hunters harvest data, 1976 to 1979. Wildlife Management Harvest statistics, Department of Recreation and Conservation, Victoria, B.C.

B.C. Hydro. 1977. Stikine Development: Project Overview Study. Hydrology Report No. DD102.

B.C. Hydro. 1978a. Preliminary Environmental Assessment of Hydroelectric Development on the Iskut River, B.C. Environmental Resources Department. Progress Report No. 1. November 1978.

B.C. Hydro. 1978b. Preliminary Environmental Assessment of Hydroelectric Development on the Stikine River, B.C. System Engineering Division, Environmental Resources Department. Report SE 7815. November 1978.

B.C. Hydro. 1978(c). Iskut Development: Project Overview Study. Hydrology. Report No. DD109.

B.C. Hydro. 1980/82. Stikine/Iskut Land Use Inventory. Properties Division, Vancouver.

B.C. Hydro and Power Authority. 1980. Stikine-Iskut Rivers Hydroelectric Project Environmental Feasibility Studies - Economic Geology. SED Report No. SE 8005.

B.C. Hydro. 1981. Stikine-Iskut Hydroelectric Development. Feasibility Study. Hydrology, River Regime and Morphology. Report No. H1110.

B.C. Hydro. 1982a. Hydrology, River Regime and Morphology. Addendum Report on Water Temperatures. Report No. H1406.

B.C. Hydro. 1982b. Hydrology, River Regime and Morphology. Addendum Report on Suspended Sediment. Report No. H 1463.

B.C. Hydro. 1982c. Hydrology, River Regime and Morphology. Addendum Report on Test Reaches. Report No. H1581.

B.C. Hydro. 1983a. Stikine-Iskut transmission project - terms of reference, environmental and socio-economic studies. Environmental and Socio-economic Services, Report No. ESS-72.

B.C. Hydro. 1983b. Hydrology, River Regime and Morphology. Addendum Report on Ice Observations. Report No. 1606.

B.C. Hydro and Power Authority. 1984a. Stikine-Iskut Development, Iskut Canyon and More Creek Projects, Interim Reservoir Shoreline and Breakline Studies. Preliminary Draft. Report No. H 1681.

B.C. Hydro. 1984b. Stikine-Iskut Hydroelectric Development. Downstream Water Temperature Study. Report No. H1700.

B.C. Hydro 1984c - Stikine-Iskut Development, Report on Stage 1 Settlement Studies. Report No. H 1544.

B.C. Hydro and Power Authority. Not dated. Geological Factors Affecting Seismicity for the Iskut Project. File Document.

B.C. Ministry of Environment. 1977. British Columbia administrative boundaries for wildlife management. Map Production Division, Survey and Mapping Branch, Victoria, B.C.

B.C. Ministry of Environment. 1982. Surveys and Resource Mapping. Terrain Features Maps and Reports for 104F, G, H (North 1/3), B (North 1/2). Scale 1:25 000.

Canadian Resourcecon Ltd. 1982. "Stikine-Iskut Project: Social and Economic Impacts"; August 1982. Unpublished preliminary consultant report to B.C. Hydro.

Chartrand, N., C. Demers, M. Giguere et R. Verdon. 1983. Juxtaposition des lignes en milieu naturel. Service Ecologie biophysique, Vice-presidence Environnement, Hydro Quebec, Mai 1983.

Craighead, F.L., E.L. Young and R.D. Boertje. 1984. Stikine River moose study - wildlife evaluation of Stikine-Iskut dams. Report prepared by Alaska Dept. of Fish and Game, Juneau, Alaska.

Crouter, R.E. and I.S. Todd. 1965. Stikine River exploratory fish program. Fish. Mar. Serv. Vancouver, B.C., 1978.

Currie, Coopers & Lybrand Ltd. 1982(a) "Base Line Socio-economic Data for the Village of Hazelton and the District of New Hazelton, submitted to Alcan Co. of Canada Ltd.", 1982.

Currie, Coopers & Lybrand Ltd. 1982(b) "Base Line Socio-economic Data for the Town of Smithers and the Village of Telkwa, submitted to Alcan Co. of Canada Ltd.," 1982.

DPA Consulting Ltd. 1981. "Northern Transmission Lines Socio-economic Study - Northwest Section", March 1981. Consultant report prepared for B.C. Hydro.

DPA Consulting Ltd. and Juan de Fuca Environmental Consultants. 1982. Stikine-Iskut hydroelectric development, recreation and tourism study. Draft preliminary consultant report prepared for B.C. Hydro, Vancouver.

DPA Group Inc. 1984. A Study of Stikine hunting estimates. Draft consultant report prepared for B.C. Hydro, Vancouver, May 1984.

Doerr, J.G. 1983. Home range size, movements and habitat use in two moose, Alces alces, populations in southeastern Alaska. Can. Field Nat. 97:79-88.

Environmental Land Use Committee British Columbia 1977 - Guidelines for Linear Development. March 1977.

Environment and Land Use Committee 1978 - Guidelines for Benefit Cost Analysis. 1978.

Environment Canada. 1951-80. Atmospheric Environment Service. Canadian Climate Normals. Temperature and Precipitation 1951 to 1980.

Eikos Group - 1983 - Stikine-Iskut, General Land Use Studies, B.C. Hydro, Vancouver. Unpublished preliminary consultant report to B.C. Hydro.

Erickson, R. 1983. Stikine-Iskut transmission project. Environmental studies - wildlife study summary. 3 volumes. Prepared for B.C. Hydro, Vancouver, 31 October 1983.

Erickson, R. A. Edie and G. MacKinnon. 1983a. Stikine-Iskut transmission corridor wildlife winter survey; February 8 to 11 1983. Prepared for B.C. Hydro, Vancouver, February 1983.

Erickson, R., L.A. Goulet and S. Houseknecht. 1983b. Stikine-Iskut transmission corridor wildlife survey, March 14 to 18, 1983. Report prepared for B.C. Hydro, Vancouver, 2 volumes.

Forestal International Limited. 1980. Forest Impact Study. Stikine-Iskut Environmental Studies. Unpublished preliminary consultant report to B.C. Hydro.

Forestal International Limited. 1982a. Addenda to Stikine-Iskut Forest Impact Study.

Forestal International Limited. 1982b. Addendum to Stikine-Iskut. Forest Impact Study. Project Memorandum No. 1. Effects of Reservoirs on Viability of Future Logging in Surrounding Areas.

Foster, H.D. and W.N.D. Sewell. 1981. Water: The Emerging Crisis in Canada. James Lorimer and Co. Publishes and Canadian Institute for Economic Policy. Toronto. 117 pp.

Franzel, J. and K.A. nelson. 1981. Stikine River Eulachon. USDA Forest Services. Alaska Manuscript Report.

Fuhr, B. and D.A. Demarchi. 1982. Cry Lake ungulate biophysical map (104-I). B.C. Ministry of Environment, Terrestrial Studies Branch, Victoria, B.C. 1982.

Geotex Consultants Ltd. March 1983. 1983 Report; Forrest Kerr Fault System and Related Faults. Consultant report to B.C. Hydro.

Gorman, W. 1982. Habitat utilization by ungulates and other wildlife in the proposed reservoir areas on the Stikine and Iskut Rivers - a summary report of the 1979 and 1980 field studies. Environmental and Socio-economic Services, B.C. Hydro, Vancouver, Report No. ESS-25.

Goulet, L.A. 1978. Vegetation and wildlife of the Stikine River September 1977 (inventory only). Environmental Resources Department, B.C. Hydro, Vancouver, mimeo report, 46 pp.

Goulet, L.A. 1984. Stikine-Iskut transmission project - an overview wildlife survey of a selected route, September 1983. Unpubl. data, Environmental and Socio-economic Services, B.C. Hydro, Vancouver, B.C.

Government of B.C. Heritage Conservation Branch. 1983. Guidelines for Heritage Impact Assessment in British Columbia.

Grove, Edward, W. April 1984. Geological Report on Certain Structural Features in the Iskut Region. 35 p.

Hamilton, Hugh. 1982. Northern Transmission, Stikine Study Area. Forestry Resources.

Hanson, W.C. 1981. Caribou encounters with pipeline in northern Alaska. Can. Field Nat. 95(1):57-62.

Hart, J.L. 1973. Pacific fishes of Canada. Fish. Res. Board of Canada. Ottawa, 1973, Bull. 1980.

Hatler, D. 1981. Study by the Spatsizi Association for Biological Research. 1980/81 Progress Reports No. 1 through 9. Reports completion of phase 1 Stikine/Spatsizi caribou telemetry project.

Hatler, D.F. 1983. Studies of radio-collared caribou in the Spatsizi Wilderness Park area, British Columbia. Spatsizi Association for Biological Research, Smithers, B.C. Report No. 2 January 1983.

Hayward, Ian & Associates Ltd. 1982. Preliminary Environmental and Social Impact Assessment of the Stikine/Iskut Transmission System. 4 Vol.

Heglund, P.J. and D.H. Rosenberg. 1984. Waterbird investigations and vegetation descriptions of the Stikine River and adjacent wetlands. Report prepared by U.S. Fish and Wildlife Service, Special Studies, Anchorage, Alaska.

Hydro Quebec. 1981. Etude d'impact de la traversee due ravage de cerfs de Virginie de Hill Head, premiere et deuxieme lignes a 735 kV due Complexe de la Grande. Direction de l'Environment, Dec. 1981.

IEC/Beak Consultants Limited. 1983a. Analyses of the potential impacts of hydroelectric development of the Stikine River system in Alaska. Addendum on Eulachon Spawning. Unpublished preliminary consultant report prepared for B.C. Hydro.

IEC Beak Consultants Limited. 1983b. Analyses of the potential impacts of hydroelectric development of the Stikine River system in Alaska. Addendum on Salmon utilization of Floodplain Habitats. Unpublished preliminary consultant report prepared for B.C. Hydro.

IEC Beak Consultants Ltd. 1984. Analyses of the potential impacts of hydroelectric development of the Stikine River system in Alaska. Addendum on Fisheries and Hydrology studies. Unpublished preliminary consultant report prepared for B.C. Hydro.

International Environmental Consultants 1982. Wildlife studies for Stage I, northern transmission line route selection studies Stikine transmission project. Prepared for B.C. Hydro, August 1982, 67 pp.

Irvine, J.R. 1977a. Preliminary study on aquatic resources relative to hydroelectric development on the Stikine River. Draft consultant report to Envir. Res. Dept., B.C. Hydro.

Irvine, J.R. 1977b. Preliminary study on aquatic resources relative to hydroelectric development on the Iskut River. Draft consultant report to Envir. Res. Dept., B.C. Hydro.

Jackson, R.D. 1983. Waterbird investigations of the Stikine River and adjacent wetlands. Part 1. Hydroelectric project impacts on Stikine River Ecosystems - an overview. Report prepared by U.S. Fish and Wildlife Service, Special Studies, Anchorage, Alaska.

Jones, D.P. and B.C. Hydro. 1984. Stikine-Iskut Development. Environmental Hydrology Report. Hydrology, sediment transport and morphology of the Stikine and Iskut Rivers. Unpublished preliminary consultant report prepared for B.C. Hydro.

Jones, M.L. and P.T.P. Tsui. 1979 Fisheries investigations in the vicinity of proposed hydroelectric reservoirs in the Stikine and Iskut Rivers in Northwestern British Columbia. Draft report to B.C. Hydro by Aquatic Environments Limited, Calgary. 164 pp.

Joyal, R., P. Lamothe and R. Fournier. 1984. L'utilization des emprises de lignes de transport d'energie electrique par l'orignal en hiver. Can. J. Zool. 62:260-266.

Kalman, H. 1980. The Evaluation of Historic Buildings. Parks Canada, Ottawa.

Kellerhals, R. 1982. Effect of river regulation on channel stability. In: Hey, R.D., J.C. Bathurst and C.R. Thorne, Eds. Gravel-Bed Rivers: Fluvial Processes, Engineering and Management. John Wiley & Sons, New York. 685-715 pp.

Klein, D.R. 1971. Reaction of reindeer to obstruction and disturbances. Science 173:393-398.

Klohn-Leonoff Consultants Ltd. 1980. Stikine-Iskut Hydroelectric Development. Feasibility Study, Preliminary Shoreline Assessment. Report No. VA 2550. Prepared for B.C. Hydro and Power Authority.

Klohn-Leonoff Consultants Ltd. 1982. Stikine Site Z and Tanzilla Reservoir Studies, Stikine River Area, B.C. Report No. VA 2801. Prepared for B.C. Hydro and Power Authority.

Klohn-Leonoff Consultants Ltd. 1983. Stikine Canyon Reservoir Studies - Addendum to Report of Investigations 1981. Report No. PB 7014-0110. Prepared for B.C. Hydro and Power Authority.

Lamothe, P. 1984. Effets des emprises de lignes de transport d'electricite sur l'original en hiver. 20th Moose Conference, April 30-May 4, 1984, Quebec City.

Leopold, L.B. October 1969. Landscape Esthetics How to Quantify the Scenics of a River Valley. Natural History Magazine.

Lenihan, P.J. et al. 1978. The preliminary report of the National reservoir inundation study. U.S. Dept. of the Interior. National Parks Service. Southwest Cultural Resources Centre. Sante Fe, New Mexico.

Life-Space Designs Ltd. 1981a. Visual Analysis of the proposed Stikine River Hydroelectric Project. Unpublished preliminary consultant report to B.C. Hydro.

Life-Space Designs Ltd. 1981. Northern Transmission Studies - Sitkine-Iskut/Prince George - Visual Analysis.

Marr-Terr Enviro Research. 1981. Relationships between mountain goat ecology and proposed hydroelectric development on the Stikine River, B.C. Report No. MT1. Unpublished preliminary consultant report prepared for B.C. Hydro, Vancouver, B.C.

McCart, P. 1980. Report of fish surveys in reservoir areas Stikine and Iskut drainages, 1980. Unpublished preliminary consultant report prepared by Aquatic Environments Limited for B.C. Hydro.

McDaniels Research Ltd. 1983. Stikine-Iskut Hydroelectric Development Resource Evaluation Study. Draft consultant report to B.C. Hydro. June 1983.

(MEMPR, 1982). Ministry of Energy, Mines and Petroleum Resources, 1982. Guide to the Energy Project Review Process.

Mohs, G. 1977. Arrow Lakes region; post inundation studies of the archaeological resources. B.C. Hydro, Vancouver.

Moore, L.F., Egri, C., Vanderbeck, M. 1975. Voluntary Action in B.C.: An Analysis of Communities in the Northwest Region. Voluntary Action Resources Centre, 1975.

(NNRS 1979) Northern Natural Resource Service Ltd. 1979. Stikine-Iskut Aquatic Ecological Studies, 1978: Downstream Sections. Draft consultant report to B.C. Hydor.

Pedology Consultants. 1983. Soil, Surficial Geology and Landforms Inventory of the Stikine-Iskut Hydroelectric Project. Unpublished preliminary consultant report prepared for B.C. Hydro.

Penner, D.F. and P. Jalkotzy. 1982. Studies on furbearing mammals of the Stikine-Iskut River drainages, British Columbia. Unpublished preliminary consultant report prepared for B.C. Hydro, Vancouver, by McCourt Management Ltd.

Points West Heritage Consulting Ltd. 1981. Heritage Resource Stage 1 Impact Assessment. 1981.

Points West Heritage Consulting Ltd. 1983. Heritage Potential Determination and Research Summary, Stikine-Iskut Transmission Study. 1983.

Province of British Columbia. 1982. "The Northwest Region ABC Regional Economic Study", 1982.

Rich, W.H. and E.M. Ball. 1933. Statistical review of the Alaska salmon fisheries. Bull. U.S. Bureau Fisheries 47: p. 556.

Richardson, T.H. and N.D. Johnston. 1966. Stikine River Red Salmon Studies Alaska Dept. Fish and Game. Information booklet No. 86, 25 pp.

Ryder, J.M. 1984. Terrain Inventory for the Stikine-Iskut Area (NTS 104G, 104F and Parts of 104B and 104H. B.C. Ministry of Environment. Surveys and Resource Mapping Branch. 85 p.

Schaefer, D.G. 1975. Climatic fluctuations in the Fraser Delta-Steveston, British Columbia 1896-1974. Paper presented to the 9th annual congress of the Canadian Meteorological Society, University of British Columbia, Vancouver, B.C. 19 pp.

Schaefer, D.G. 1976. Climatological Impacts of Peace River regulation and Review of the possible effects of climatic change on agriculture in the area. Report prepared for B.C. Hydro, Scientific Services, Atmospheric Environment Service. 60 pp.

Schultz International Limited. 1979. A background study of available knowledge. The lower Stikine River and Estuary, Alaska. Report prepared for B.C. Hydro.

Schultz International Ltd. and Ford, Thornton, Norton and Associates Ltd. 1983. Development of a Reservoir Water Quality Model for Reservoirs in British Columbia. Unpublished preliminary consultant report to B.C. Hydro.

Schultz International Limited - Ford Thornton Norton & Associates Limited. 1984a. Stikine-Iskut Hydroelectric Development. Effect of submerged weir algorithm on outflow temperatures. Unpublished preliminary consultant report prepared for B.C. Hydro.

Schultz International Limited - Ford Thornton Norton & Associates Limited. 1984b. Stikine-Iskut Hydroelectric Development. Simulation of Selective withdrawal and its effects on release temperatures. Unpublished preliminary consultant report prepared for B.C. Hydro.

Sigma Environmental Consultants Ltd. July 1982. Preliminary Fisheries Impact Assessment of the Stikine-Iskut Transmission System.

Stewart, A. 1982. Dease Lake (104J) and Telegraph Creek and Sumdum (104G, F partly) ungulate biophysical maps. B.C. Ministry of Environment, Terrestrial Studies Branch, Victoria, B.C.

Talisman Land Resource Consultants. 1982. Agricultural Overview, Stikine-Iskut Hydroelectric Development. Unpublished preliminary consultant report to B.C. Hydro.

Talisman Land Resource Consultants. September 1983. Inventory data compiled for Stikine-Iskut Transmission detailed agriculture study. Draft consultant report to B.C. Hydro.

Talisman Land Resource Consultants. February 1984. Interim Report. Agricultural Impact Assessment, Stikine-Iskut Hydroelectric Development. 50 pp.

Talisman Land Resource Consultants. 1984b. Stikine-Iskut Hydroelectric Development. Wildlife Habitat Mapping Study. Unpublished preliminary consultant report to B.C. Hydro.

Techman Engineers Ltd., and Ceska Geobotanical Research Co. 1983. Stikine and Iskut River Basins Vegetation Studies.

Technology Resource Inc., P. Ward and Associates Ltd. and Ford, Thornton and Norton & Associates Ltd. 1984. Stikine-Iskut Hydroelectric Development: Simulation of Selective Withdrawl and Its Effects on Release Temperatures. Unpublished preliminary consultant report to B.C. Hydro.

Tera Environmental Consultants Ltd. 1982(a). Northern Transmission Line Studies - Vegetation: Stikine/Iskut Section.

Tera Environmental Consultants 1982(b). Northern Transmission Line Studies - Agriculture: Stikine/Iskut Section.

Tera Environmental Consultants Ltd. 1983. Stikine/Iskut Transmission Line Vegetation Study.

Tera Environmental Consultants Ltd. and J.M. Ryder & Associates. October 1983. Stikine-Iskut Transmission Studies Terrain Mapping: Iskut Valley, Ningunsaw Pass, and Bell Irving Valley. 14p plus Appendices. Corridor Section Maps at 1:50 000 scale.

Tetlow, R.J. and Sheppard, S.R.J. 1977. Visual Resources of the Northeast Coal Study Area. Resource Analysis Branch. Ministry of Environment, Victoria.

Vanicek, P. and D. Nagy. 1980. The map of contemporary vertical crustal movement in Canada. EOS, Transactions American Geophysical Union. V.61, No. 14, p. 145-147.

Wilson, I.R. Consultants Ltd. 1984, Stikine-Iskut Development Heritage Resources Impact Assessment - Summary Volume Permit 1983-35. Unpublished preliminary consultant report.

Wyborn, M. 1981. Caribou survey data and snow depth in vicinity of Spatsizi Plateau, 1980. Environmental and Socio-economic Services, B.C. Hydro, Vancouver, Report ESS-13.

SECTION 6.0 - MITIGATION AND COMPENSATION

6.1 HYDRO'S APPROACH TO MITIGATION AND COMPENSATION

B.C. Hydro is committed to minimizing adverse environmental and socio-economic impacts that could result from the Stikine-Iskut development. Having determined the impacts of a development, Hydro seeks to ameliorate them by undertaking mitigation measures or compensation programs. Mitigation means modifying or controlling the development in some manner in order to lessen the impact while compensation means making payments to individuals, groups or government to redress impacts which cannot reasonably be mitigated. An example of mitigation would be to provide facilities in the dam to release additional water at certain times in order to reduce impacts on fish or downstream users. An example of compensation would be to provide the funds required to construct and operate a fish hatchery to compensate for loss or disruption of spawning habitat.

Hydro's approach on mitigation and compensation stems primarily from the benefit-cost guidelines prepared by the British Columbia Environment and Land Use Committee Secretariat (E.L.U.C.) in 1977. This document sets out the principles to be used in project evaluation, including impact evaluation, and provides the framework for making mitigation and compensation decisions. Based on the benefit-cost guidelines, in February 1980, Hydro published guidelines covering its approach to mitigation and compensation issues along with an illustration of their application to the Peace Site C project. Subsequently, in July 1980, E.L.U.C. published its own guidelines on mitigation and compensation. As both sets of guidelines are based on benefit-cost principles, they are in considerable agreement. However, the E.L.U.C. guidelines emphasize the need for payments to be used in the most efficient manner economically without particular regard for other considerations whereas Hydro's approach emphasizes the need for the payments to ensure that those who are impacted most, e.g. people in the project area, do not lose disproportionately to the rest of the people in the province. Basically, Hydro's approach is that compensation should go to those affected, be these individuals owners, local groups or government agencies responsible for the impacted resource. In the case of a government agency, the funding should be tied to specific programs in the region affected. Hydro also believes that compensation payments must bear a reasonable relationship to the value of the resources affected. With reference to mitigation measures, Hydro's approach is that these should be undertaken so long as benefits from reduced impacts exceed the costs incurred.

In the report on the Site C hearings, the Site C panel of the British Columbia Utilities Commission made recommendations concerning mitigation and compensation and commented on Hydro's approach and the E.L.U.C. guidelines. However, in handing down its decision to refuse Hydro's application to construct the Site C project, the cabinet neither endorsed nor rejected these recommendations. Accordingly, as there is yet no clear government directive on mitigation and compensation, Hydro in its planning and work on the Stikine-Iskut development, has incorporated the approach set out above. Sections 6.2 and 6.3 below set out, in further detail, this approach both in general and as applied to the Stikine-Iskut development.

6.2 MITIGATION

6.2.1 GENERAL

The mitigation measures which can be undertaken to reduce the impacts of the Stikine-Iskut development fall into three major categories. First, there are those measures which have been incorporated in the project description as a result of interaction at the study stage between those engaged on the engineering design and those engaged on the environmental studies. This process is described in Section 2.1.6. Second, there are those measures which will be undertaken as part of Hydro's standard procedures and practices. Third, there are site specific measures which have been suggested and which Hydro will consider further when studies resume.

Hydro's environmental assessments are based on the mitigated development, i.e. on the impacts of the development after these mitigation measures which have been agreed to at the time of the assessment have been incorporated. There is little point in assessing potential development impacts which will not occur because they have been eliminated by a mitigative procedure during the exploration, construction or operation phases. Accordingly, the interim assessment given in this report is based on a development including the mitigation measures incorporated or agreed at this time. Future agreement by Hydro to incorporate other mitigation measures will be reflected in the final assessment.

6.2.2 INCORPORATED MEASURES FROM ENGINEERING-ENVIRONMENTAL INTERACTION

Engineering and environmental studies are carried out simultaneously and become more detailed with time. As environmental problems are identified they may be eliminated or practically mitigated by incorporation of appropriate design considerations. This evolution of a mitigated development is said to occur by an "iterative process", since there are usually many generations of the development description. In the case of the transmission component, the project description becomes progressively more refined through the corridor and route selection stages of study.

The iterative process to date has contributed to the identification of the featured development presented in this report. Examples of mitigation measures already incorporated in the development are presented in Table 6-1. The process is incomplete for the generation component in that the results of detailed environmental studies have not been applied fully. Similarly for the transmission component, detailed engineering, environmental and socio-economic studies remain to be completed as part of the detailed route selection studies.

6.2.3 STANDARD PROCEDURES AND PRACTICES

B.C. Hydro is committed to minimizing adverse environmental and socio-economic impacts that could result from its projects. To effectively implement this commitment, Construction Environmental Procedures Manuals have been prepared.

These manuals provide both the administrative framework and technical guidelines for good field practice whereby protection of environmental resources would be achieved during construction.

The program would be implemented as follows: when authorization to proceed with project construction is obtained, environmental resource protection requirements, identified during project assessment and approval stages, would be assembled into a commitments list. This would then be used to prepare contingency plans, appropriate clauses in construction contracts and other documentation useful in the conduct of the work, e.g. environmental index maps.

During the progress of work, compliance with environmental clauses of contracts would be assured through the use of environmental inspectors. Their duties, authority and reporting requirements are provided in the manuals.

Guidelines for Good Practice describe practical guidelines and proven techniques for use by the design and construction personnel in the preparation for, and conduct of, the construction work. They include measures for general resource protection, e.g. wildlife, heritage resources, in addition to advice on environmental protection methods available for use during the construction of, for example, access roads, stream crossings, borrow areas, camps, etc.

The above procedures are standard for all construction work undertaken by B.C. Hydro. Accordingly they have been taken into account during project assessment studies and impacts have been predicted in the knowledge that protection measures as described in the manuals would be implemented.

6.2.4 POTENTIAL SITE SPECIFIC MITIGATION MEASURES

As a result of the detailed environmental studies on the generation projects and preliminary studies on the transmission projects, several mitigation recommendations additional to those now incorporated have been made. A summary of these recommendations is given in Table 6-2. Undoubtedly, further recommendations will surface as detailed environmental and socio-economic studies are completed and as suggestions are received from the public. Where possible benefit-cost analysis will be used to assess the viability of recommended mitigation measures.

6.3 COMPENSATION

6.3.1 PRIVATE PROPERTY

Construction of the Stikine-Iskut development would flood various areas in which individual citizens or Crown agencies have an interest including one property owned in fee simple; in addition several properties could be affected by the transmission lines.

B.C. Hydro will not seek to implement any program of property acquisition unless and until the necessary hearing process and licencing procedure has been followed and the development authorized.

Compensation in accordance with prevailing legislation and case law should be paid to all owners whose land and/or interest therein is affected. Hydro will endeavour to ensure that the amount of compensation achieved through negotiation is equivalent to that which the owener could reasonably expect to receive under formal expropriation procedures.

6.3.2 INFRASTRUCTURE

Hydro would relocate Highway 37 where necessary and build a new crossing of the Stikine. Relocation of the B.C. Rail grade would depend on the future use planned.

6.3.3 GUIDING TERRITORIES AND TRAPLINES

The construction of the Stikine-Iskut development would impact a number of registered traplines and guide territory operations.

There are nine traplines located in the generation project area which could be impacted. In addition, traplines along the transmission line route could also be affected. Effects on traplines range from complete loss because of flooding to temporary disturbance of furbearer populations. In order to compensate registered trappers for these losses in a fair and consistent fashion, Hydro, in conjunction with the British Columbia Trappers Association and the British Columbia Fish and Wildlife Branch, has developed a program that compensates for losses caused by Hydro's activities. It contains measures to compensate trappers on an individual basis for losses related to trapping as a livelihood or business venture. It pays compensation for loss of harvest and loss of presently used cabins, cubbies, traps and trails on the trapline. It covers impacts caused by the study and exploration and operation stages. Where there is permanent habitat loss on some portion of a trapline resulting from a project, the program provides incentives to the trapper to continue trapping on the remaining portion of the trapline.

There are seven guide territories in the generation projects area together with an additional number along the transmission line. Construction of the Stikine-Iskut Development would impact these by flooding wildlife habitat and affecting wildlife populations. In addition, disturbance of hunting activities and loss of trails and improvements may occur. Hydro at present does not have an equivalent to the Registered

Trapline Program for guide outfitters. Historically, Hydro has paid compensation for real property losses and damages to improvements.

6.3.4 RESOURCES

There are a number of opportunities in the development area where Hydro could provide facilities or undertake programs to compensate for resource losses caused by the development. Some of these are listed below:

Recreation

To compensate for the recreational losses that would be caused by the Peace River Site C project, Hydro offered to fund a 50-unit campground with an adjacent 50 vehicle picnic site and a boat launch ramp, a boat launch ramp at the damsite, two small day use facilities and various wilderness type campsites along the reservoir and on other rivers in the region. It is foreseen that similar facilities could be offered on the Stikine and Iskut reservoirs. Boating facilities would be particularly valuable on the Tanzilla reservoir which would be flanked on both sides by towering canyon walls for most of its length. It has also been suggested that a road be provided along the Stikine Canyon Reservoir from Highway 37 east to the upper part of the reservoir. This would permit vehicular access for those using the upper Stikine River or the reservoir. However, the effect on wildlife populations caused by hunters using this access would have to be considered. Listed below are some facilities which will be considered by Hydro.

(i) Tanzilla Dam Area

1. Sheltered viewpoint of damsite.

2. Boat launch facility for Tanzilla reservoir.

3. Hiking trail west of Tanzilla dam along canyon rim.
4. Trails along canyon rim linked to Tanzilla powerhouse.
5. Lakeside picnic area on a small lake between dam and powerhouse.

(ii) Stikine Canyon Dam

1. Covered view facility of dam.
2. 6 km trail along north rim of canyon.
3. Boat launch near Highway 37 crossing of the reservoir.
4. Short recreational trails to small lakes off Stikine Canyon dam access road.

(iii) Iskut Canyon

1. Sheltered viewpoint of dam.
2. Campsite and trail to Tom Mackay upland.

(iv) More Creek

1. View site and interpretive centre at More Creek damsite.
2. Access to Devil Lake and other small lakes in the vicinity.

Fisheries

Fisheries afford a number of opportunities for compensation programs. Hatcheries and rearing ponds can be provided to enhance salmon populations. The provision of artificial spawning channels is another technique used to enhance salmon populations. In the Stikine-Iskut basin there are a number of streams including the Tuya and Tanzilla rivers to which fish access is blocked by impassable barriers. Removal of these barriers or provision of fishways around them could also form part of an enhancement program. The Tuya River and Tuya Lake could be made accessible to salmon and could support substantial populations of several species. Preliminary estimates indicate spawning capacity of 48,000 chinook, 67,000 coho, and 200,000 sockeye salmon. Steelhead trout may also find the drainage a satisfactory spawning and rearing area.

Social

Two major areas where compensation programs could redress adverse social impacts are the provision of electric power to local communities and the provision of the jobs to local people. With regard to the provision of power, Hydro already provides power from diesel generation to Iskut Village, Telegraph Creek and Dease Lake. Although Hydro heavily subsidizes its diesel generation operations, capacity is limited and higher rates are charged for consumption above a certain level to discourage electric heating with high cost diesel generation. Hydro has therefore made the commitment that if the Stikine-Iskut development went ahead, these communities local to the generation sites would be connected to the provincial grid or else be treated for billing and other purposes as if they were. The latter situation could arise if the cost of transmission and transformer facilities from the new development exceeded the cost of continuing diesel generation for local people. With reference to jobs Hydro would support programs to increase the scope and level of these opportunities for local people. Such programs could include training and special agreements with the construction unions. Other programs to compensate for adverse social impacts could include improvements to medical and recreational facilities for existing communities and improvements to infrastructure such as access and water supply. The extent of such programs would depend on the magnitude of the impact.

Forestry

It is foreseen that any funds that Hydro was required to provide to the Ministry of Forests as compensation for loss of forest land could be used on intensive silviculture and site rehabilitation programs.

TABLE 6-1

STIKINE-ISKUT HYDROELECTRIC DEVELOPMENT
MITIGATION ACCEPTED IN FEATURED DEVELOPMENT

Item Accepted	Potential Impact Addressed	Justification	Implementation Time Frame
Area 1 - DOWNSTREAM			
A. Fisheries			
(a) Provide low level and service outlets to maintain riparian flows (Stikine Canyon, Tanzilla, Iskut Canyon); More Creek has service outlets only	Reduced spawning and/or rearing habitat for fish during reservoir filling	Migitation - design component to provide adequate water releases during reservoir filling	Construction
(b) Provide flip bucket spillway at Stikine Canyon, Tanzilla and Iskut Canyon; weir/plunge pool at More Creek	Gas supersaturation effects on fish and potential for high energy water erosion on terrain	Mitigation - design components to dissipate water energy and reduce potential gas supersaturation	Construction
(c) Reservoir releases during initial filling would be greater than or equal to 10 percent of mean annual discharge at damsite during winter months (February to April); thereafter (May to October), releases would be 30 percent	Dessicated and/or frozen spawning redds; tributary access problems for spawners; reduction of useable juvenile rearing habitat	Mitigation - provide sufficient water for spawning and rearing during reservoir filling	During reservoir filling
(d) Rapid changes in discharge during reservoir filling from turbine testing would be avoided	Stranding of fish, particularly juveniles; tributary access problems; exposure of redds to dessication/freezing	Mitigation - provide sufficient water for spawning and rearing during reservoir filling	During reservoir filling
(e) Provide a small amount of live storage in Tanzilla Reservoir so that Stikine Canyon and Tanzilla can be operated somewhat independently	Rapid stage fluctuations leading to fish stranding; potential negative effects on availability of food for fish; potential deleterious effects on spawning fish behaviour	Mitigation - Tanzilla reservoir would be used as a re-regulating structure for downstream releases	Operations

TABLE 6-1 - (Cont'd)

Item Accepted	Potential Impact Addressed	Justification	Implementation Time Frame
(f) Rates of change of powerflows from Tanzilla will be reduced to limit stage changes at Stikine River above Butterfly Creek to a rate to be established	Stranding of fish; exposure of spawned redds to freezing/dessication; potential effects on fish food availability	Mitigation - downstream discharge variability would be minimized	Operation
II AREA 2 - DAMSITE AREA			
A. Recreation/Tourism			
(a) All merchantable timber will be removed and all non-merchantable timber larger than 7.5 cm in diameter will be felled or knocked down, piled and burned in all areas above the minimum reservoir level and in areas where the tree tops are 5 m or less below the minimum reservoir level	Unsightly snags and navigation dangers on reservoirs due to submerged trees	Mitigation - clearing standards to facilitate recreational use of reservoirs	Construction
B. Heritage			
(a) All sites identified in reservoirs will be described, evaluated and/or excavated as per Heritage Conservation Branch guidelines	Loss of historic or archeological sites	Mitigation - preservation of heritage information in the development area	Construction
(b) If Site HaTj3 would be affected by flooding, determine Indian band's preference regarding reinterment. Provide new site if desired	Possible disturbance of burial site	Mitigation	Prior to Construction

TABLE 6-1 - (Cont'd)

Item Accepted	Potential Impact Addressed	Justification	Implementation Time Frame
III AREA 3 - SELECTED TRANSMISSION ROUTE			
A. Wildlife			
(a) Stikine Canyon to Bob Quinn Collector (km 100-115) - transmission line moved east increasing distance between transmission line and Highway 37	Damage to important wildlife habitat near km 104; visual impacts in former location	Mitigation - avoidance of important wildlife habitat and reduction of visual impacts	Construction
(b) Iskut Canyon to Bob Quinn Collector (km 0-22) - line moved to east side of Iskut River (subject to technical verification)	Damage to goat and moose habitat; visual impacts in former location	Mitigation - avoidance of important wildlife habitat and reduction of visual impacts	Construction
B. Visual			
(a) Bob Quinn Collector to Telkwa Substation (km 19-20) - line moved to northwest, closer to highway	Obstruction of views east of Highway 37	Mitigation - reduction of visual impacts	Construction

TABLE 6-2

STIKINE-ISKUT HYDROELECTRIC DEVELOPMENT
POTENTIAL MITIGATION MEASURES (TO BE EVALUATED)*[1]

Item Considered	Potential Impact Addressed	Justification	Implementation Time Frame
I AREA 1 - DOWNSTREAM			
A. Fisheries - Hydrology			
(a) Release water from Stikine Canyon and More Creek reservoirs to minimize diversion closure interruptions of downstream flows at Tanzilla and Iskut Canyon, respectively	No water release from Tanzilla and Iskut Canyon areas for short periods during diversion closure	Mitigation - prevent low water conditions and fisheries and other water use concerns	Reservoir filling
(b) Make provision for release of water from More Creek reservoir during filling if at any time during the winter discharge of the Iskut River at Snippaker Creek falls below those which have been recorded under natural conditions	Release flows contribute to water levels below naturally occurring minimums causing fish habitat loss and potential exposure and freezing of salmon redds	Mitigation - provide lowest recorded water flows as a minimum	Reservoir filling
(c) Make provision for release from the reservoirs of 30 percent of mean annual flow at the damsite if fish access to tributaries is impaired by insufficent mainstem discharge during reservoir filling	Access blocks to migrating salmon especially during spawning	Mitigation - provide sufficient water to prevent obstructions	Reservoir filling
(d) Reduce fluctuations in Tanzilla and Iskut Canyon powerhouse discharges during April and May to limit stage changes at Stikine River above Butterfly Creek and Iskut River below Johnson River to a maximum of 15 mm/h; at other times to less than 150 mm/6 h	Fluctuating stage responsible for stranding of newly emergent salmon fry and juveniles; deleterious effects on fish flood availability and spawning behaviour	Mitigation - reduce variation in flows to near levels which occur naturally in this system	Operation

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*[1] Project deferment and the curtailment of studies precluded the investigation of these potential mitigation measures.

TABLE 6-2 - (Cont'd)

Item Considered	Potential Impact Addressed	Justification	Implementation Time Frame
(e) Avoid total shutdown of flows downstream of dams during the filling period (or any other time). If, however, plant shutdowns are unavoidable, whenever possible arrange shutdowns to coincide with peaks in tributary flow to make up for losses in flow from upstream. Arrange rates of decline in flow if they can be controlled, to be the lowest practically achievable to reduce the incidents of stranding of juveniles or spawning fish	Reduction of fish spawning and rearing habitat; stranding of juvenile fish	Mitigation - provide sufficient water and reduce flow fluctuations to prevent fish impacts	Reservoir filling and operation
(f) Adopt AEL's (1982) detailed suggestions to mitigate the impacts of short-term fluctuations in discharge including: - Minimize the magnitude of water level fluctuations, particularly reductions in level. This is especially important 1) during periods when flows are already in a low range, and 2) during critical period in the life history of fish - Control the rates at which reductions in flow occurs to allow fish to move with receding shoreline and reduced the frequency of stranding. Using stage discharge relationships at various points downstream of dams on the Stikine and Iskut rivers and the information on the depth distribution of fish,	Stranding of juvenile fish; interference with spawning behaviour	Mitigation - minimize flow fluctuations in critical periods of fish life cycles	Operation

TABLE 6-2 - (Cont'd)

Item Considered	Potential Impact Addressed	Justification	Implementation Time Frame
determine what changes and rates of discharge at the damsite would be appropriate to protect juvenile and adult salmon in their areas of concentration			
- Avoid extremes in discharge and water level fluctuations in May and early June when fry are newly emerged, are in very shallow water, are incapable of rapid movement, and are very vulnerable to stranding			
- Wherever possible, time discharge reductions such that, in areas of concentration of juvenile fish, they occur during daylight hours			
(g) Temperature effects may be largely mitigated through the provision of multiple intakes, at several depths, so that water of the appropriate temperature can be drawn off at will, to maintain an appropriately normal temperature regime downstream. Such a system would probably be most effective during summer when stratification, if it occurs, will provide relatively large volumes of both warm and cold water. It would be least effective during the winter when the volume of water corresponding to the temperature of natural streamflow (0°C for most of the winter) may occupy only a relatively small volume immediately under the ice cover	Premature emergence of salmon fry; potential reductions in juvenile salmon growth rates	Mitigation - reduce salmon fry mortality due to premature fry emergence; reduce influence on growth rates	Detailed design

TABLE 6-2 - (Cont'd)

Item Considered	Potential Impact Addressed	Justification	Implementation Time Frame
(h) Changes in the wetted areas of ponds and small lakes in the floodplain used by rearing coho salmon (as well as waterfowl and moose) could be controlled through the construction of small stoplog dams. These dams would replace beaver dams in areas where beaver are no longer active. Barnes Lake is a prime example of such a site.	Reduced habitat for spawning and rearing fish	Mitigation - provide habitat for fish which is hydrologically related to the mainstem rivers	Construction

TABLE 6-2 - (Cont'd)

Item Considered	Potential Impact Addressed	Justification	Implementation Time Frame
II AREA 2 - DAMSITE AREA			
A. Terrain			
(a) Use of Area 1 for aggregate source for the Stikine Canyon is preferred	Inefficient use of terrain resources; unnecessary terrain impacts	Mitigation - reduce amount of terrain disturbance requiring reclamation	Construction
Use Box Canyon spoil material for dam construction if possible			
Use Area 3 aggregate source for More Creek project preferentially to Area 2			
(b) Avoid construction in the Spruce-Willow-Birch and Tundra zones and minimize disturbance of organic terrain, and on lava beds in the Iskut Canyon area	Long-term (permanent) terrain impacts	Mitigation - reduce terrain disturbance	Construction
B. Vegetation			
(a) Minimize the amount of clearing in development and ancillary facilities areas	Excessive vegetation disturbance	Mitigation - minimize vegetation disturbance and later needs for reclamation	Construction
C. Agriculture			
(a) Maintain or provide alternative access to remaining agricultural and grazing lands	Development blockage of access to agricultural or grazing land	Mitigation - preserve access	Construction
(b) Adopt a land acquisition and flood reserve policy that secures only lands directly required for the project	Reduction of agricultural land base in the region	Mitigation - remove impediments to development of agricultural land	Application

TABLE 6-2 - (Cont'd)

	Item Considered	Potential Impact Addressed	Justification	Implementation Time Frame
D.	Forestry			
	(a) Allow sufficient period for logging of reservoirs to permit organized and cost effective operation	Waste of forest resources in reservoirs	Mitigation - minimize the resources cost of the development	Construction
E.	Fisheries			
	(a) Stikine to Bob Quinn transmission line (km 8-20). Examine terrain stability and develop special construction plans to protect fish rearing and spawning habitat.	Construction damage to important fish spawning and rearing habitat	Mitigation - protect important fish resources	Detailed study
	(b) Recommend that Fish and Wildlife Branch develop plans to prevent excessive development-related use of Morchuea, Eddontenajon, Kinachon, Tatogga and Kiniskan Lakes, which are important to native food fishery	Degradation of native food fishery resources	Mitigation - prevent depletion of important fisheries resource	Detailed study
	(c) Stikine Canyon to Bob Quinn transmission line (km 119 to Bob Quinn Collector) - design and develop access in conjunction with directives from Fish and Wildlife to manage fishing impacts on previously inaccessible lakes	Excessive sport fishing of previously inaccessible lakes	Mitigation - develop access to be compatible with fisheries management plans	Detailed study
F.	Wildlife			
	(a) Avoidance of critical and important wildlife habitat during final transmission route selection activities	Interference with critical and important wildlife habitat	Mitigation - minimize impacts on wildlife	Route selection

TABLE 6-2 - (Cont'd)

Item Considered	Potential Impact Addressed	Justification	Implementation Time Frame
(b) Hand clearing at major creek crossings; leave shrub vegetation which does not effect safety of transmission lines	Reduction of amount of riparian habitat; lack of wildlife cover at streambank	Mitigation - minimize impacts on wildlife	Construction
(c) Control amount of vehicle access in areas of importance to wildlife; use of helicopters where possible during construction, rather than road access; preventing post-construction road access where possible	Increased hunting pressure and wildlife disturbance due to increased road access	Mitigation - minimize impacts on wildlife	Construction and operation
G. Recreation/Tourism			
(a) Stabilize areas of reservoir shoreline which are activated by reservoir filling in areas of interest	Unstable terrain impacts limiting recreation opportunities	Mitigation - optimize recreation/tourism value of the development	Reservoir filling and operation
H. Visual Resources			
(a) Re-route transmission line to avoid sighting from Highway 37. Areas to be considered: - Stikine Canyon to Bob Quinn (km 25, Highway 37 crossing) - Tanzilla to Stikine (km 0-25, access road and transmission line should be assessed)	Visual impacts	Mitigation - avoid construction of line in areas which have high visual value	Detailed planning
(b) Apply visual enhancement measures in areas where transmission line re-routing is not possible; can also be considered for other development disturbances; examples are:	Visual impacts	Mitigation - reduce the visual impact of the development	Construction

TABLE 6-2 - (Cont'd)

Item Considered	Potential Impact Addressed	Justification	Implementation Time Frame
- use of planted vegetation screens			
- feathering and contouring vegetation on right-of-way edges			
- minor route deflections to adhere to land contours			
Areas to be considered are:			
- Eddontenajon to Todagin Creek (km 38-64)			
- Stikine to Bob Quinn (km 100-120)			
(c) Iskut to Bob Quinn (km 21-33) - reroute access road and transmission line	Obstruction of views of northwest side of Iskut Valley	Mitigation - reduce visual impact	Detailed Planning
I. Heritage			
(a) Evaluative testing is recommended for materials borrow areas if they are selected to be part of the development (potential sites are: H1Tm 1, H1Tm 4 and IaT1 7, 10, 12, 15)	Disturbance or destruction of heritage sites	Mitigation - comply with Heritage Conservation Branch guidelines	Prior to construction
(b) Excavate Site IaT1 2	Disturbance or destruction of heritage sites	Mitigation - comply with Heritage Conservation Branch guidelines; contains data of scientific significance	Prior to construction
(c) Further excavation of Site IaTm 1	Disturbance or destruction of heritage sites	Mitigation - comply with Heritage Conservation Branch guidelines; a multicomponent site which has raised several research questions	Prior to construction

TABLE 6-2 - (Cont'd)

	Item Considered	Potential Impact Addressed	Justification	Implementation Time Frame
	(d) Obtain informant interview of Site IaTl 4	Disturbance or destruction of heritage sites	Mitigation - comply with Heritage Conservation Branch guidelines	Prior to construction
J.	**Land Use**			
	(a) Combine access road and transmission line routes in Klastline Plateau area between Highway 37 and the Stikine collector station	Disturbance of visual, terrain and recreation resources	Mitigation - reduce the amount of disturbance due to access and optimize location	Detailed planning
	(b) Coordinate Stikine-Iskut development access with that of other developments:	Disturbance of terrain wildlife and visual resources	Mitigation - minimize the amount of disturbance due to access and construction	Detailed planning
	- More Creek access with Schaft Creek mine access			
	- Iskut Canyon access with mining ventures in Snippaker Creek area			
	- Access in Bob Quinn area should consider forestry access requirements			

TABLE 6-2 - (Cont'd)

Item Considered	Potential Impact Addressed	Justification	Implementation Time Frame
K. Socio-Economic			
(a) Allow adequate time in studies phase to allow for involvement of local residents (including settlement options)	Lack of public participation and understanding of project impacts	Mitigation - increase opportunity for public participation	Detailed study
(b) Provide adequate information about the development before licence application to assist with local and regional planning	Delays of schedule due to time involved in incorporating the development in local and regional plans	Mitigation - avoid development delays	Detailed planning
(c) Provide training opportunities to enhance local employment	Difficulty of employment for local people in semi skilled or skilled jobs	Mitigation - enhance employment opportunities for local people	Construction
(d) Protect to extent possible isolation of existing settlements, if desired	Socio-economic impacts on existing isolated communities from construction work force	Mitigation - respond to planning objectives of local communities	Detailed planning
(e) Provide aid to local residents to take advantage of business opportunities, both from direct B.C. Hydro contracts and indirect services	Lack of ability of local residents to compete for secondary business benefits from the development	Mitigation - avoid disproportionate impacts on local community	Construction
(f) Control traffic flows in populated areas to minimize disturbance	Increased vehicle traffic and noise	Mitigation - avoid traffic conflicts with local residents	Construction

TABLE 6-2 - (Cont'd)

Item Considered	Potential Impact Addressed	Justification	Implementation Time Frame
III AREA 3 - SELECTED TRANSMISSION ROUTE (Bob Quinn to Telkwa Substation)			
A. Agriculture			
(a) Goathern Creek to Telkwa Substation (km 339-373) - construct new lines to south of existing lines and cut and tie new lines in	Proposed lines would displace farm buildings at km 368 and glance cleared land near km 345	Mitigation - avoid interference with agricultural operations	Construction
B. Fisheries			
(a) Vicinity of Kitseguecla River (km 280-287) - conduct geotechnical study of area and determine detailed site-specific clearing, access and construction specification	Terrain failure causing impacts on fish migration	Mitigation - prevent terrain and fisheries impacts	Detailed study
C. Wildlife			
(a) Vicinity of Hanna and Tintina Creek (km 122-132) - re-route line around bog area	Disturbance of important/critical moose wintering, grizzly bear and fish spawning and rearing habitat	Mitigation - prevent disturbance of wildlife habitat	Route selection
(b) Vicinity of km 150-180 - develop access in consultation with Fish and Wildlife Branch to assist in management of resources	Potential overharvesting of wildlife and fish in previously inaccessible area	Mitigation - minimize access - effects on wildlife resources	Detailed study
D. Recreation/Tourism			
(a) Bob Quinn Collector Station - move collector station to south, possibly across the Ningunsaw River and locate transmission line away from Bob Quinn and Desiree lakes	Combined visual, land use and recreational impact from transmission lines converging at large substation	Mitigation - avoid impacts on visual and related resources	Route selection

TABLE 6-2 - (Cont'd)

	Item Considered	Potential Impact Addressed	Justification	Implementation Time Frame
E.	Visual			
	(a) Retain vegetation screens adjacent to Highway 37 and feather or contour clear along right-of-way edges to screen short-range views. Specific areas are: - Vicinity of Alger Creek (km 15) - Vicinity of km 35, 200-245, 271-272	Long-range views impaired by short-range sighting of transmission towers	Mitigation - preserve aesthetic quality	Construction

SECTION 7.0 - DEVELOPMENT ALTERNATIVES

7.1 GENERAL

Chapters 3, 4 and 5 of this report have described and assessed full development of the Stikine and Iskut rivers with the the specific alternative featured. However, as was stated in Chapter 3 these project alternatives may not be the one finally put forward in an application for an energy project certificate. Therefore, this chapter considers other project alternatives and assesses how the impacts of these differ from the impacts of the featured alternative. In addition to considering the different impacts which could be caused by differences in individual projects, this chapter also considers the effects of partial or phased construction of the development; that is construction of only some of the four generation projects which form the total development. Phased or partial development could be preferred under certain future conditions. Environmental or social considerations may lead to one or more of the projects being delayed until unknown impacts can be determined. Equally, delay or omission of one or more projects from the development may be preferred for financial reasons as it would reduce the amount of funds that have to be committed at one time. This chapter considers the two most likely partial development alternatives; the two Stikine River projects alone and the two Iskut projects alone.

7.2 DEVELOPMENT ALTERNATIVES

7.2.1 STIKINE PROJECTS ALONE

Calculations based on Table 7-1 indicate that the unit cost of energy from a partial development, incorporating only the Stikine projects, would be similar to the unit cost of energy from the total development. Construction of the Stikine projects alone would therefore be economically attractive. This partial development would be considered if construction of the Iskut projects appeared to be environmentally unacceptable. It is also possible that Hydro might wish to initially construct the Stikine projects and only subsequent to their completion consider the Iskut projects. This would have the advantage of reducing the size of the financial and other commitments required at one time.

Generating facilities would consist of the Stikine Canyon project and the Tanzilla project as described in Section 3.

The development of the Stikine River projects alone would provide a total of approximately 1920 MW of capacity from the Tanzilla and Stikine Canyon generating stations. The transmission facilities required to carry the power south to the system grid would be as follows:

- two 500 kV lines from each of the Tanzilla and Stikine Canyon generating sites to a collector station near Stikine Canyon (Stikine Collector).

- two 500 kV lines from the Stikine collector to Telkwa substation with an intermediate switching station located approximately mid-way between these two terminals.

Currently projected transmission system reinforcement to the Lower Mainland would consist of the following 500 kV lines:

- one line from Glenannan substation to Dash Creek substation.

- one line from Dash Creek substation to Kelly Lake substation.

- one line from Dash Creek substation to Meridian substation.

The above requirements assume the presence of the following 500 kV transmission lines; Williston - Telkwa #2, Williston - Kelly Lake #3, and Kelly Lake - Cheekye #2, See Fig. 7-1.

The route from the Tanzilla and Stikine Canyon generating sites to Telkwa substation would be the same as that described for the proposed development (Section 3.3.2) with with following exceptions:

- The More Creek and Iskut Canyon generating stations would not be required nor would the transmission lines from these sites
- The Bob Quinn Collector station would not be required
- only two 500 kV lines would be routed south of the Bob Quinn Lake area to Telkwa substation, requiring a right-of-way approximately 118 m wide.

7.2.2 ISKUT PROJECTS ALONE

Calculations based on Table 7-1 indicate that the unit cost of energy from a partial development, incorporating only the Iskut projects, would be some 25% higher than the unit cost of energy from the total development. Despite this unit cost increase, construction of the Iskut projects alone would be a competitive alternative to other energy sources being considered by Hydro. If construction of the Stikine projects was considered undesirable for environmental or other reasons, construction of the Iskut projects alone would justify consideration. Construction of the Iskut projects alone has the advantage that for an investment of about 1/3 that required for the total development, a major source of energy could be provided in the northwest of the province. Iskut Canyon and More Creek could meet all immediately foreseeable loads in the adjacent area. The connection to the grid would permit a more economic operation of these plants than if they were isolated.

Generating facilities would consist of the Iskut Canyon project and the More Creek project as described in Chapter 3.

The development of the Iskut River alone would provide a total of approximately 980 MW capacity from the Iskut Canyon and More Creek generating stations. The following transmission facilities would be required to carry this power south to the system grid:

- one 230 kV line from More Creek to Iskut Canyon
- two 500 kV lines from Iskut Canyon to the existing system at Telkwa substation. A single 500 kV line between Iskut Canyon and Telkwa substation would be a high risk due to its great length (405 km)
- an intermediate switching station would be required at the approximate mid-point between Iskut Canyon and Telkwa substation.

Current preliminary studies indicate that no transmission system reinforcement would be required to the Lower Mainland. This is based on the assumption that the second Williston-Telkwa 500 kV line, the third Williston - Kelly Lake 500 kV line, and the second Kelly Lake - Cheekye 500 kV line would already be in-service, see Fig. 7-2.

The route from Iskut Canyon generating station to Telkwa substation would be the same as that described for the proposed development (Section 3.3.2) with the following exceptions:

- there would be no Bob Quinn Collector
- the 230 kV line from the More Creek site to Iskut Canyon would parallel the two 500 kV lines on the east side of the Iskut River
- only two 500 kV lines would be located south of the Bob Quinn Lake area to Telkwa substation, requiring a right-of-way approximately 118 m wide.

7.3 ALTERNATIVE PROJECT ARRANGEMENTS

7.3.1 STIKINE CANYON

(a) Alternative Arrangement with Arch Dam in Box Canyon

This layout is essentially the same as the Featured Project Arrangement Layout, but with the box canyon rockfill dam replaced by an arch dam and an auxiliary spillway with a shorter chute at the right flank of this arch dam.

Arrangement of galleries within the dam and the abutments, foundation and abutment drainage, grouting, and foundation treatment, apart from some special concrete infilling, would be generally as described for the main canyon arch dam.

The auxiliary spillway headworks would be virtually the same as for the featured alternative, but the approach channel and chute would be much shorter. The chute would be only 100 m long terminating in a flip bucket at El. 720. Spillway releases would be thrown onto the most downstream portion of the box canyon immediately before the major bend in the river channel. Prior removal of box canyon overburden in this area is assumed.

(b) Alternative Single Embankment Dam Arrangement

This layout, would consist of a single rockfill dam across the Stikine Canyon a short distance downstream from the box canyon; facilities in the river and left abutment for river diversion during construction of this dam; low level, intermediate level and high level (service spillway) outlets within the left abutment; an auxiliary chute spillway at the right flank of the dam; and power intake, penstocks, underground powerhouse and tailrace tunnel located within the right abutment below and downstream of the dam.

This embankment dam, approximately 290 m high would consist of upstream and downstream rockfill shells with a central impervious core inclined slightly upstream.

The river would be diverted through two tunnels in the left abutment capable of passing a 30-year frequency design flood of 2580 m^3/s.

A permanent intermediate level outlet facility would be required for reservoir level control and riparian flow releases during initial reservoir filling, following closure of the low level outlets. The intermediate level outlets could also be used in conjunction with the high level outlet for emergency, partial reservoir evacuation.

The high level outlet (service spillway) would be provided for normal flood releases; control of reservoir levels and flow releases during the final stages of reservoir filling, as well as for periods of powerplant shutdown; and for emergency, partial reservoir evacuation purposes.

The auxilary spillway would have a curved approach channel, a control structure with three radial gates and a straight rectangular chute terminating in a flip bucket.

The powerhouse would be located under the rock promontory just downstream with the power intake located on the easterly side of this rock mass and accessed from the right bank portion of the rockfill dam by a bridge.

Flow from the three draft tubes would be conveyed back to the river via a draft tube manifold/gate chamber and a single tailrace tunnel, which would discharge downstream of the service spillway plunge pool.

With this layout the Tanzilla Project reservoir and dam would be lowered by 19 m. This represents a significant reduction in Tanzilla Project dam cost to be accounted for in scheme comparisons.

7.3.2 TANZILLA

(a) Alternative Arrangement with Sluices in Arch Dam

This layout is essentially the same as the Featured Project Arrangement, but with the three intermediate level outlets and the auxiliary chute spillway replaced by five spillway sluices within the arch dam, and with the plunge basin weir eliminated.

The five sluices would be arranged in a staggered pattern between mid-height and to 2/3 height below the crest.

The spillway sluices would be utilized for all floods, releases during the higher stages of reservoir filling, emergency reservoir evacuation purposes, control of reservoir levels and flow releases during powerplant outages.

(b) Alternative Project Arrangement with a Central Core Rockfill Dam

The principal project features would consist of a rockfill dam; facilities in the river and right abutment for river diversion during construction; an intermediate level (service spillway) outlet within the left abutment; and an auxiliary chute spillway at the right flank of the dam.

This rockfill dam, approximately 208 m in height, would consist of upstream and downstream rockfill shells with an impervious core inclined slightly upstream.

The river would be diverted through two free-flow tunnels in the right abutment capable of passing a 30-year frequency design flood of 2630 m^3/s.

Low level outlet facilities would be provided in one of the diversion tunnels for releasing riparian flows and control of reservoir levels during initial reservoir filling, to facilitate final closure of diversion works, and to be used with other hydraulic facilities for emergency, partial reservoir evacuation when the reservoir level is within the design operating range for these low level outlet gates.

The intermediate level tunnel outlet would be used for normal flood releases. Releases would be thrown into a partially pre-excavated plunge pool in the river channel. An auxilary surface spillway would be used only when flood releases exceed the capacity of the intermediate level outlet.

(c) Alternative Arrangement with a Concrete Faced Rockfill Dam

The principal project features would be the same as in the control core rockfill dam alternative except that the central core would be replaced by a concrete face.

This embankment dam would have an approximate maximum height of 205 m.

The concrete facing would vary in thickness from 0.3 m to 0.85 m. Special attention would be paid to joints in the concrete face with extra provisions of water barriers near the perimeter and above discontinuities in the dam's foundation surface. The concrete face would be reinforced throughout with steel continuous through some of the joints.

7.3.3 ISKUT CANYON

(a) Alternative Arrangement with a Concrete Arch Dam

This arrangement would include a concrete arch dam with base plug and thrust blocks; wing dams; plunge pool weir; a diversion tunnel and cofferdams, low level outlet and intermediate level outlets (service spillway) in the arch dam; an auxiliary spillway; a saddle dam with adjacent fuse plug spillway and power facilities. The Saddle Dam, fuse plug spillway and power facilities would be identical to those described for the Featured Project Arrangement.

(i) Arch Dam

The Iskut Canyon arch dam would consist of a thin arch 157.5 m high founded on a concrete plug in the narrow canyon and abutting concrete gravity thrust blocks in the upper part. The arch would have a crest length at El. 350.0 of 160 m and would vary in thickness from 3 m at the crest to 12.5 m at the base. Low and intermediate level outlets would be installed in the lower portions of the arch.

The embankment wing dams would be constructed with a central impervious core and sand/gravel shells with transition, filter and drain zones. The embankment wing dams would have a maximum height of about 50 m on the right and 30 m on the left. The corresponding crest lengths would be 200 and 250 m respectively.

The auxiliary spillway would be located in the left concrete gravity wing dam. It would be a conventional gated structure discharging water into a short concrete-lined chute and flip bucket.

(b) Alternative Arrangement with a Concrete-Faced Gravel Embankment

This alternative would consist of a concrete-faced sand/gravel embankment dam in the main canyon with appurtenant structures to the dam, saddle dam, discharge facilities and power facilities the same as for the Featured Project Arrangement.

(i) Main Embankment Dam

The main embankment dam would be constructed from sand and gravel, with rockfill in the downstream toe. The dam crest length and height would be about 640 and 180 m respectively.

The embankment dam would have a concrete face having a 0.3 m thickness at the crest and increasing by 0.003 of the water depth to 0.8 m at the lowest point. A bedding layer, well graded, compacted and bound with shotcrete, would be provided on the upstream face of the embankment to support the concrete facing.

7.3.4 MORE CREEK

(a) Central Core Embankment Dam with Left Bank Spillway

This project arrangement would consist of a sand and gravel embankment dam with an impervious core, a diversion tunnel adapted for a low level outlet; a surface spillway on the left bank; and power facilities. The power facilities would be the same as described for the Featured Project Arrangement.

This embankment dam would be approximately 145 m high and have a near central impervious till core sloping slightly upstream.

The discharge facilities would comprise a low level outlet constructed in the diversion tunnel and a concrete-lined surface spillway on the left abutment of the dam.

(b) Concrete Faced Embankment Dam with Left Bank Spillway

This project arrangement is comparable to the layout discussed in (a) with the same hydraulic and power facilities, and differs only in substituting a concrete-faced sand/gravel embankment for the central core embankment.

The concrete facing would vary from 0.3 m thick at the crest increasing by 0.003 of the water depth to 0.75 m at the lowest point. A bedding layer, well graded, compacted and bound with shotcrete, would be provided on the upstream face of the embankment to support the concrete facing. An impervious blanket and sand/gravel shoulder would be built on top of the lower part of the concrete facing to provide an additional water barrier in the deepest part of the reservoir where repair of the concrete facing would be difficult.

(c) Central Core Embankment Dam with Right Bank Spillway

This project arrangement is also comparable to the layout discussed in (a) in terms of diversion, low level outlet and power facilities; however, the surface spillway would be constructed on the right abutment with the rock excavation necessary for the spillway utilized in the downstream shell of the impervious core embankment.

7.3.5 TRANSMISSION ALTERNATIVES

(a) General

An alternative to the transmission system described in Section 3 would be to have one of the three transmission lines running south from Bob Quinn Collector join the grid at the Skeena Substation near Terrace. This alternative would provide backup power supply to the Terrace and Prince Rupert areas in case of trouble with the present transmission system east of Terrace.

The single line to the Skeena substation could either be:

1) a line branching off the proposed route from Bob Quinn Collector to Telkwa or

2) a separate new line from Telkwa to Skeena (Telkwa River Route).

The former alternative with a line branching off the route between Bob Quinn and Telkwa could take either of two forms:

1) a line branching off near Cranberry Junction and heading south directly to Skeena (Cranberry Junction to Skeena Route) or,

2) a line branching off on the South side of the Skeena River and heading Southwest to Skeena via Zymoetz River (Zymoetz River Route).

The routes referred to are described in Sections b, c and d below, and shown in Fig. 7-3.

The need for backup system support in the Terrace area will depend on whether the Kemano Completion project is developed. If it is, the additional power developed would likely be transmitted through the B.C. Hydro grid to the proposed new smelter site near Vanderhoof. It would therefore also provide a source of energy in the Terrace area if there was a failure in the system east of Terrace.

(b) Cranberry Junction to Skeena Substation

This is the preferred route to Skeena and branches off the route to Telkwa 11 km north of the Van Dyke airstrip. The distance between the proposed Bob Quinn Collector and Skeena Substation via this route is approximately 333 km. The route gradually descends about 100 m, passing the Van Dyke airstrip on the east side and moves closer to Highway 37. The route remains about 1 km away and runs parallel to the highway to a point 13 km south of Van Dyke where it crosses and heads south away from the highway.

The route continues south over heavily treed, undulating terrain to Borden Lake where it turns west and crosses the Cranberry river and the New Aiyansh access road. It then skirts the base of Kiteen Ridge, initially crossing rocky terrain, then traverses extensively logged slopes along the access road leading to Nass Camp. The route continues along the base of the Hazelton Mountains avoids the settlement of New Aiyansh and heads south along the wide, bowl-shaped Tseax river valley. The route parallels the existing 138 kV line for about 5 km and then turns east to follow Sterling Creek, avoiding the Lava Lake-Sand Lake area. The route leaves Sterling Creek and enters the valley of the Cedar and Kitsumkalum rivers. After crossing the Cedar River in two locations the route joins the existing 138 kV right-of-way approximately 3 km north of the Kitsumkalum River crossing. The route parallels the existing line to Skeena Substation except for minor deviations to avoid a small lake and to allow for other transmission lines near the Skeena Substation. The route passes through the Kitsumkalum Recreation Reserve and ski area, then crosses the Skeena River. High towers would be required on both sides of the river crossing to maintain clearance between the conductors and high water. The terrain throughout this section is gently rolling with heavy forest cover which has been extensively logged in certain areas. There is good existing access throughout the length of the route.

(c) Zymoetz River Route

An alternate route to Skeena substation branches off the route to Telkwa Substation approximately 1 km south of the Kitsequecla River Crossing and then turns west towards Kitsuns Creek. It follows Kitsuns Creek, rising to 1200 m near its headwaters where the proposed transmission line could be exposed to heavy ice and wind loading for about 4 km. The route crosses the east side of the Zymoetz River where it remains for about 9 km before crossing to the west side where it continues to the confluence of the Zymoetz River and Limonite Creek.

The preferred route from the Limonite Creek and Zymoetz River confluence to Skeena Substation would pass under the existing 500 kV circuit and continue for about 6 km adjacent to that line. The route then diverges south and crosses the Zymoetz River and a natural gas pipeline, then crosses the Clore River and heads southwest towards Trapline Creek. It then climbs over moderate terrain to the headwaters of Trapline Creek. As the route approaches the headwaters of Trapline Creek it traverses a flat ridge at El. 1160 m and enters the Williams Creek valley following the north side to avoid avalanches off the mountains to the south. The route then crosses Williams Creek to avoid a settlement to the north and enters the Skeena River valley. The route crosses level, lightly treed river deposits for 3 km then climbs onto a plateau to join the existing 500 kV right-of-way which it parallels to Skeena Substation. The distance from the proposed Bob Quinn Collector to Skeena Substation following this route is 404 km.

Skeena Substation is designed to accommodate an additional 500 kV line entering from the northeast. More specific routing of the transmission line into the substation will depend on other potential developments such as the Kemano expansion and the proposed 500 kV Skeena-Rupert line to the west.

(d) Telkwa River Route

A third route to Skeena Substation originates at Telkwa Substation and parallels the existing 500 kV and 138 kV lines and the proposed route from the three lines from the Bob Quinn Collector to a point about 1.5 km north of the Telkwa River crossing. The route diverges to the west, climbs to the headwater of Cummings Creek at El. 1300 m, then descends to rejoin the existing 500 kV line at Sinclair Creek. This route has been selected to avoid a large earth movement which is threatening the existing line halfway between Cummings and Jonas creeks.

7.4 ENVIRONMENTAL IMPLICATIONS

7.4.1 DEVELOPMENT ALTERNATIVES

(a) Stikine Projects Alone

A scenario of developing the Stikine projects alone eliminates direct local effects of the Iskut component of the featured development but, owing to its size and location, retains most of the regional biophysical and socio-economic effects. Elimination of the Iskut projects would prevent flooding of approximately 6000 ha of land and alienation of about 770 ha of land due to transmission lines. Additional reductions in land requirements would be associated with the reduced requirements for ancillary site facilities such as camps, airstrips and work area (386 ha). The amount of land disturbance reduced is approximately one third of the total for the featured development. The transmission line right-of-way width would be reduced from 172 m to 118 m. Details indicating the change in the amount of impact beyond obvious reductions for elimination of the Iskut project facilities are summarized below.

(i) Agriculture

Potential agricultural impacts due to generation projects are almost entirely associated with the Stikine component and no significant impact reduction would occur with development of the Stikine project alone.

Agricultural impacts due to transmission lines would be reduced with the Stikine development alone because one of the three 500 kV lines would not be required. The reduction in impacts is due primarily to the reduction in tower interference.

(ii) Forestry

The reduction in land disturbance from deleting the Iskut development results in a 34 percent reduction in the amount of forest land lost due to reservoirs and further reduction of approximately 700 ha of forest land eliminated by transmission rights-of-way. Timber volumes and requirements for harvesting and salvaging would be correspondingly reduced.

(iii) Water Resources

A. Hydrology

Approximately 18 percent of the mean annual discharge of the Stikine River near Wrangell would be regulated by construction and operation of the Stikine projects. The changes in the physical environment on the Stikine River previously described in Section 5.0 for the featured Stikine-Iskut development would still occur except that any changes on the Stikine River downstream of the confluence with the Iskut River would be reduced.

Floods at Stikine River near Wrangell with a 2 year recurrence interval would be reduced about 14 percent in the spring and summer and less than 1 percent in the fall (Jones et al., 1984). Fluctuations in discharge and water level attributable to normal powerplant operation would not be noticeable on the lower Stikine River, most effects of operations being limited to the reach upstream of the Porcupine River confluence.

B. Sediment Transport and River Morphology

Based upon estimates of the annual suspended sediment load between 1978 and 1982, the annual suspended sediment budget of the Stikine estuary with the Stikine projects alone would be reduced between 3 to 14 percent with a long-term mean reduction of about 8 percent (Jones et al., 1984). An 8 percent reduction in the amount of sediment delivered to the estuary would result in a slight reduction in the rate of forward extension but the estuary would continue to grow larger.

Changes in river morphology on the lower Stikine River downstream of the Iskut River confluence would be generally small and within the natural variability which has occurred during the last 30 years.

(iv) Aquatic Resources

All potential fish impacts for the Stikine River above the Iskut River confluence as described in Section 5.0 would remain unchanged. Below this confluence, impacts are likely to be reduced, as Iskut River inflows will moderate changes in the river hydrology. Water temperatures and flow regimes will be closer to normal and within the range of natural variability in the portions of the Stikine River below the Iskut confluence.

(v) Wildlife

With the development of the Stikine projects alone total wildlife impacts would be generally reduced as the Iskut valley would not be flooded. The wildlife populations in this area especially the grizzly bears would not be affected. However the major impacts of the Stikine-Iskut development are associated with the flooding of the Stikine reservoir and these would remain. Impacts downstream of Stikine dams would also remain.

With the development of the Stikine projects only two transmission lines rather than three would be required between the Bob Quinn collector and the Telkwa substation.

Accordingly the required right of way would be narrower which would reduce the habitat losses anticipated.

(iv) Recreation

Major recreation resources in the featured development area are found primarily in the Stikine Canyon and reservoir areas. Therefore, local and non-local recreation use impacts for the Stikine alone development would be unchanged or only slightly reduced from those of the entire development.

(vii) Land Use

As the majority of active traplines, guiding territories and subsistence-related activities occur in the Stikine river area, there would be few reductions in land use impacts with a Stikine projects alone development compared with an Iskut projects alone development. However, potential development in the Bob Quinn area would be greatly reduced.

(viii) Socio-economic

A. Local

The impacts to the local area will be basically the same as for the integrated development, except that Bob Quinn Lake would not expand as a community. The only effects to Bob Quinn would be the result of increased traffic flow along Highway 37.

B. Regional

The effects on the regional area would be similar since the development would still incorporate both generation and transmission components. However, since the scale of the development would be reduced, it is logical to assume a similar reduction in the expected impacts.

(b) Iskut Projects Alone

Without the Stikine projects, there would be a reduction in approximately 11 200 ha of reservoir area, 2000 ha of transmission line right-of-way and 721 ha required for ancillary facilities. Land disturbances would be reduced to approximately one third of that expected for the featured development. Additional environmental effects of the Iskut projects alone scenario are presented below.

(i) Agriculture

Agricultural impacts in the generation area would be eliminated by this alternative development.

Transmission line impacts would be reduced to some degree with the Iskut projects alone since one less line would be constructed. Reduced impacts would be due primarily to the reduction in tower interference.

(ii) Forestry

With the Iskut project alone, there would be a 65 percent reduction in the amount of forest land lost due to reservoirs, and a further reduction of about 2000 ha of land alienated for transmission line rights-of-way. There would also be reductions in timber volumes to be harvested and salvaged.

(iii) Water Resources

If only the hydroelectric potential of the Iskut River were developed, only the Iskut River and lower Stikine River downstream of the Iskut confluence would be subject to hydrology related impacts. Based upon studies discussed previously in Section 5.0, the following changes would occur.

A. Hydrology

Approximately 17 percent of the mean annual flow of the Stikine River near Wrangell would be regulated by construction and operation of the Iskut projects. Mean monthly winter flows at Iskut River below Johnson River would be increased between 2 to 4 times natural conditions while mean monthly flows at Stikine River near Wrangell would be increased between 1.3 to 3 times. The largest decrease in mean monthly discharge would occur during June and July when discharge at Iskut River below Johnson River would be reduced by a factor between 1.4 to 2.1. Mean monthly discharge of the lower Stikine river in June and July would be reduced by a factor between 1.06 to 1.16 (Jones et al., 1984). Spring and summer floods with a recurrence interval of two years would be reduced about 17 percent on the lower Iskut river and about 6 percent on the lower Stikine River. Fall floods with a 2 year recurrence interval would be reduced about 22 and 5 percent, respectively (Jones et al., 1984).

Under normal operation, occasional (estimated 1 in 10 years) interruptions in flow of short duration may occur due to emergencies such as a loss of transmission facilities. This could result potentially in a rapid decline in stage/discharge at downstream locations depending upon the time of year, tributary inflows and magnitude of powerflows at the time of the emergency. Estimates of worst case reductions in stage are presented in Jones et al., 1984.

B. Sediment Transport

Based upon estimates of the annual suspended sediment load between 1978 and 1982, the annual suspended sediment budget of the Stikine estuary would be reduced between 13 to 40 percent with a long-term mean reduction of 23 percent (Jones et al., 1984). A large portion of the fine silts and clays would remain in suspension, passing through the Iskut Canyon reservoir but changes in the particle size composition in the estuary are expected to be less than 1 percent.

(iv) Aquatic Resources

Fisheries impacts will be greatly reduced by developing only the Iskut River, since the Stikine River above the Iskut confluence contains the majority of identified fish habitat.

Downstream of the confluence impacts related to decreased sediment loads will not be reduced greatly because the Iskut carries a disproportionately large amount of the total system sediment load. The temperature regime of the lower river and estuary will be less affected if only the Iskut is developed. Flow fluctuations will be reduced below the Iskut confluence, and this will result in a reduction of potential impacts on chinook, sockeye and coho salmon.

(v) Wildlife

Construction of the Iskut projects alone would result in a substantial reduction in impacts to wildlife compared with the full development. The goat and moose populations of the Stikine valley would go undisturbed and impacts downstream of the Iskut-Stikine valley would be much reduced. However adverse impacts to grizzly bears and possibly the goat herds along the west bank of the Iskut river would remain.

Impacts due to the transmission lines would remain similar to those for the total development except that about 1/3 less load would be cleared reducing any habitat losses.

(vi) Recreation

The Iskut development alone would result in the loss of some moderate capability recreational lands. The Iskut-More Creek drainage presently sustains little recreational use, given the other opportunities in the region. The transmission development would result in disturbance of some scenic resources (that would be visible only with the access provided by the development) but would have little impact on recreation resources or use. In addition, the Iskut development alone would not have the significant visual impacts on the recreation resources along Highway 37 resulting from the transmission link from Bob Quinn to the Stikine collector stations.

(vii) Visual

As visual impacts of the Iskut development area have not been assessed, it is difficult to make an accurate assessment of an Iskut alone scenario. However, because of the low visibility of the Iskut projects, and the absence of a requirement for transmission lines north of Bob Quinn, it could be concluded that the Iskut alone scenario would have very little visible impact on the scenic resources of the region.

In addition, the Iskut River has not been recognized as an exceptional visual resource. Therefore, an Iskut development alone scenario would not result in losses of provincially significant scenic resources in this region.

South of Bob Quinn collector, the visual impacts would remain essentially the same, as reduction of the transmission line right-of-way width from 172 m to 118 m would not significantly reduce its visibility.

(viii) Land Use

The Iskut development alone would have very little impact on current or potential land use, as there are no private lands, Crown reserves and Crown leases with the exception of one ecological reserve application.

(ix) Socio-economic

A. Local

With the Iskut projects alone, there would be little, if any, induced growth in the Stikine area communities, and it is probable that the cultural/lifestyle impacts in these areas would be less critical. The effects on Bob Quinn Lake would be similar in extent to those described for the featured project. Overall, this alternative would create the lowest level of impacts in the immediate project area.

B. Regional

Regional impacts would be reduced in accordance with the smaller size of the project, compared with the overall integrated development.

7.4.2 ALTERNATIVE PROJECT ARRANGEMENTS

(a) Generation Projects

For the most part, environmental impacts for different generation project arrangements will remain unchanged. Minor site-specific differences result from the increased need for or movement of facilities such as contractor and storage areas. However, in most cases the environmental assessment of alternatives has not been completed in sufficient detail to detect overall preferences in the arrangements.

For either the Stikine or Iskut projects, the choice of concrete arch dams would be preferable from a terrain vegetation and wildlife impact perspective. This would reduce significantly the requirement for borrow material and the associated land disturbance. In addition, most borrow materials for the concrete arch alternative are available from areas that would be inundated when the development is operational.

The alternative in the Stikine Canyon, with a concrete arch dam rather than a rockfill dam in the box canyon, may be preferable in terms of terrain and wildlife. Construction time and location of facilities would be the same for either facility. However, no rock quarry would be required for Z4, therefore reducing the period of blasting and disturbance. The borrow area for impervious materials would be significantly reduced; diminished disturbance and habitat loss (if these borrow areas are located downstream or above floodlines) would result. The quantities of aggregates needed would increase, but the same aggregate borrow area would be required for the main arch dam, therefore, incremental impacts would be minimal. Overall, the alternative would have less impact on wildlife, especially for the goat populations occupying the canyon.

In terms of terrain and wildlife, the featured layout for the Stikine Canyon project is preferable to the alternative with a single rockfill dam about 1 km downstream of featured site. The latter alternative would double the need for rockfill materials, extending the period of blasting and possibly requiring a second quarry. At least twice as much impervious materials would be required, resulting in a larger borrow area. The diversion tunnel would be located on the left bank, yet dam construction would still necessitate access to the right bank. An increased period of noise and disturbance for wildlife as well as additional habitat loses (temporary since below floodlines) would result from this alternative.

At the Tanzilla damsite, the alternative with sluices through the dam does not differ from the featured project in terms of wildlife impacts. Other alternatives involve the construction of a rockfill rather than concrete dam, and the location of diversion tunnels on the right bank rather than on the left bank. Access roads and construction facilities for the featured project are all on the left bank. The alternative project would therefore involve the location of construction facilities on both sides of the river, the construction of an additional all-weather access road on the right bank, an increased need for aggregates, as well as a need for a quarry. Developments on the right bank would destroy open grass-shrub habitat on south-facing slopes which are used by wintering moose, deer and goats. The north-facing left bank is covered by a coniferous forest which is less productive in terms of wildlife. Blasting in the quarry would be disruptive to the canyon goat population but more importantly, the access road on the right bank would provide access to these wildlife populations. Increased poaching, hunting and disturbance of wildlife are likely, and in some areas, the access road may constitute a barrier to goat movement between their canyon escape terrain and their foraging habitats. The featured project, therefore, appears preferable to these alternatives.

Except the slight changes in the duration of flow interruption following diversion closure, there would be no change in the hydrological impacts if an earth embankment dam rather than a concrete arch dam were constructed at Iskut Canyon. If a low level outlet were installed in the earth embankment dam there would be no interruption in downstream flows following closure of the diversion tunnels. However, if only an intermediate level outlet were installed, flow could be interrupted for up to 3 days unless water was spilled from More Creek reservoir to raise water levels quickly in the Iskut Canyon reservoir.

(b) Transmission Line System Alternatives

A system alternative providing two transmission lines to Telkwa Substation and one line to Skeena involves consideration of the alternative routes set out in Section 7.3.5.

A discussion of significant environmental considerations on each route follows.

(i) Cranberry Junction to Skeena Substation

East of the Nass River where the route would turn to the southwest it crosses an area of volcanic kettle topography with attractive columnar showings. Consideration should be given to an alternative line location should this route be used. Forest resources are heavily used making it the least desirable segment from a forestry perspective. Valuable Aquatic resources exist where the route passes through the low lying mouth of the Cedar River near to where it enters Kitsumkalum Lake. This is an important spawning area for salmon and careful construction practice will be required to avoid adverse impacts. Moose are widely distributed throughout the area with important winter range present along the Cranberry, Kiteen, Nass, Tseax, Cedar and Kitsumkalum rivers. Access in the area is, however, well developed and incremental impacts from the transmission line would be minimal. Two areas, near Gingat Creek and the upper Stirling Creek are important to grizzly and black bears. Access control will be required here.

This alternative route has high potential for recreation. Existing resources include the Kitsumkalum Mountain Ski area and Dragon Lake east of Aiyansh. The route would come close to and be visible from both of these areas. In addition the route crosses the Tseax Lava beds between the highway and the extinct volcano making it impossible to avoid direct impact on this resource. This area is under study as a provincial park.

A small area on the fringe of existing agricultural land near Aiyansh would be affected and the present and potential agricultural land between Skeena substation and Skeena River would be affected by widening of the existing transmission right-of-way.

Several areas of alienated land would be crossed by the route; these include parcels in the New Aiyansh area, the Tseax and Kitsumkalum park reserves and between the Skeena River and substation. No Native Indian reserve land is crossed but the route is in an area claimed by the Nishgas. Concerns related to safety could be expected due to increased traffic during construction.

(ii) Zymoetz River Route

The northern portion of this route passes through areas of steep and potentially unstable terrain. Careful construction practise would be required to avoid adverse impacts on the important aquatic resources most notably in the Zymoetz River. Timber values are high and this segment of the route contains a high percentage of mature timber and medium site land compared with other segments. The dense forest contains little or no habitat for ungulates. However the upper reaches of the Zymoetz river are heavily used by spawning salmon and bear, including grizzlies, that feed on them. New access development should be limited to assist in management of these resources. There would be no impacts on agriculture, recreation, land use or socio-economic resources in the Zymoetz River area.

In the Williams Creek portion of this route, there are active logging operations near the Zymoetz River end and in the lower part of the Williams Creek drainage. Transmission Line construction would provide new access between these areas. Goat ranges on the Trapline and Williams creeks are currently unaccessible by road. Increased access to this area could mean increased hunting and poaching for the goat populations found in this drainage.

Trapline and the upper reaches of Williams Creek are not particularly important to anadromous fish. However, disturbances in these areas could adversely affect water quality downstream on Williams Creek and the Zymoetz River. In the lower reaches of Williams Creek the line lies close to the creek and careful construction practice will be required. The same applies where the line crosses the highly productive Sockeye Creek.

Although no impacts are expected in land use, agriculture, and recreation areas, the route is not recommended from a forestry perspective, as there are already several constraints to timber harvesting in this area. One of these constraints is the Ecological Reserve Application Area No. 274, a unique area of terraced bogs. This reserve is avoided by keeping the proposed route between km 100 and km 105 on the north side of the valley.

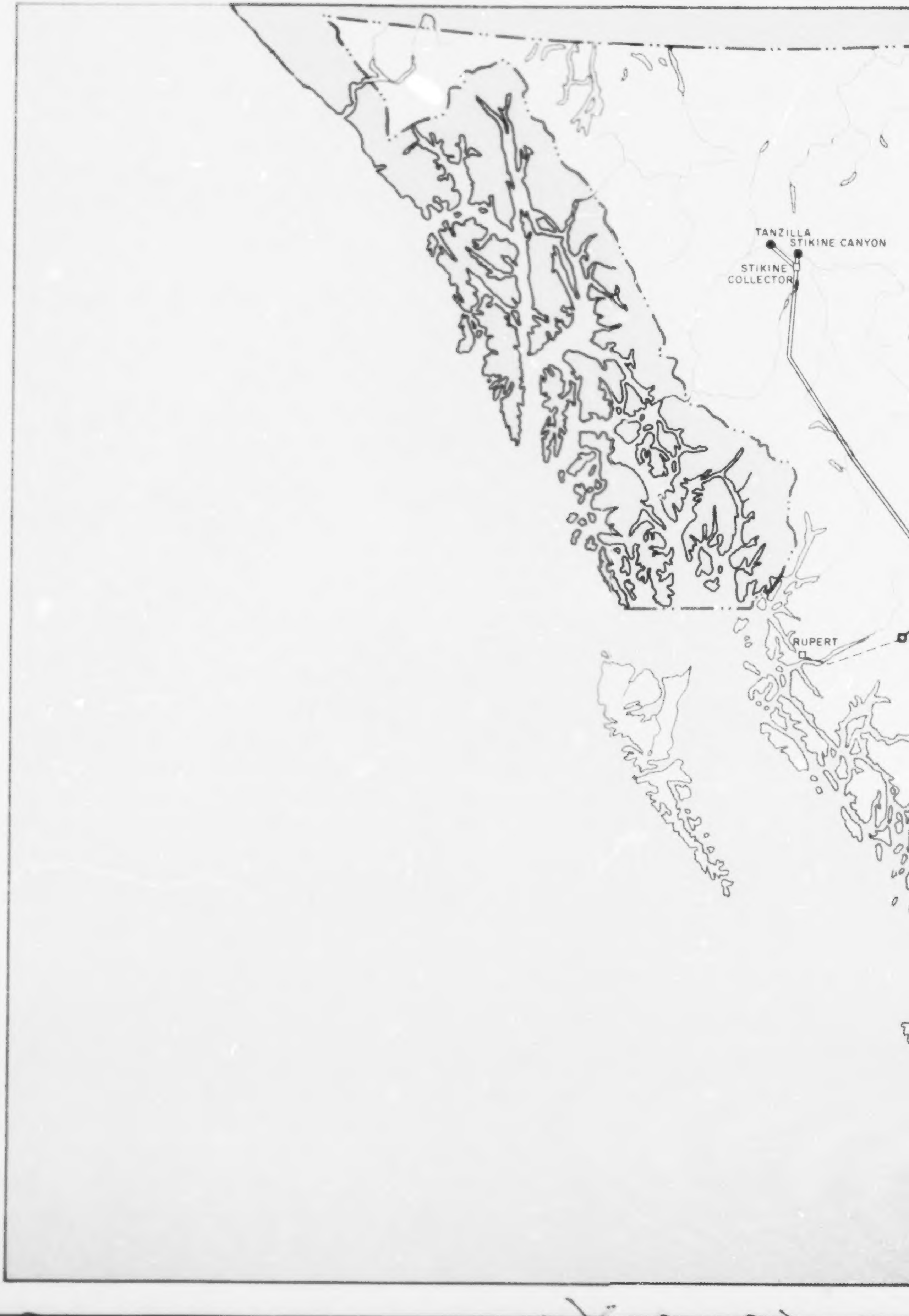
(iii) Telkwa River Route

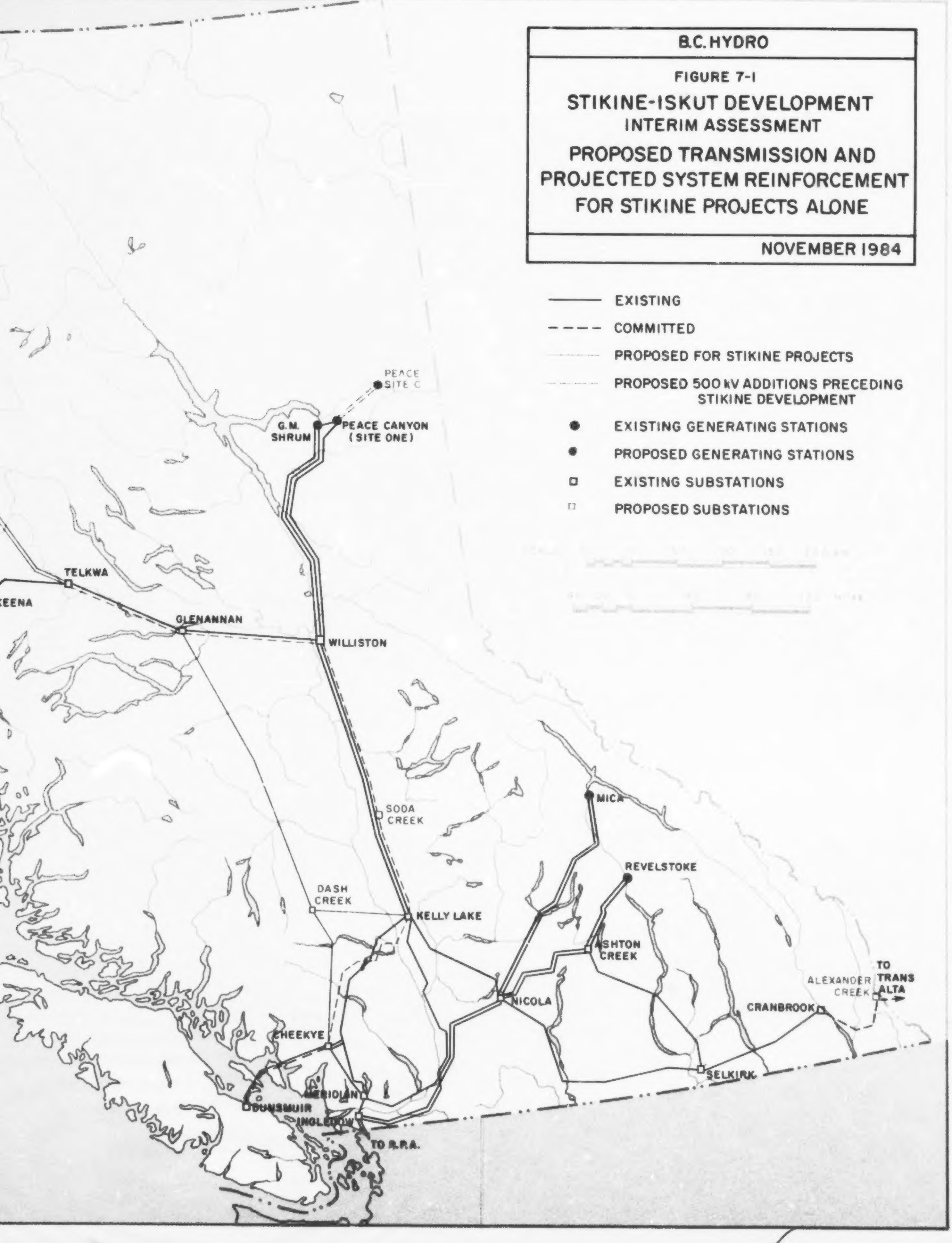
The Telkwa Route follows the Telkwa River and Pass into the Limonite Creek area and continues along, the Zymoetz River to the Skeena Substation. For most of its length, the proposed route follows an existing transmission line with the exception of the 17 km section near Cumming Creek. Winter ranges for grizzly bears and moose are found along some sections of the Telkwa River; however, these are not traversed by the selected route (1 to 5 km away). Goats occupy rocky outcrops (above 600 m) mostly on the north side of Limonite Creek roughly 0.5 km above the proposed route. Wildlife impacts in this segment should be negligible if no access is provided to the goat populations.

There are no major fisheries concerns between Telkwa Substation and Telkwa Pass. However, east of the pass the route crosses through the upper drainage of Milk Creek which contains excellent over-wintering habitat for coho spawn. Further west, Limonite Creek contains spawing habitat for coho and the route parallels the creek in very steep terrain. Construction in this area will require care if adverse impacts to these fisheries are to be avoided.

Proceeding west from the Limonite Creek area the route parallels the Zymoetz River (maximum escapement 10 000 sockeye, 5000 coho). The potential for terrain related impacts is high and careful construction practice will be required to avoid adverse effects. Between Thornhill Mountain and Skeena Substation, the route passes close to the highly productive Sockeye Creek and again special care will be required in this area to avoid adverse impacts.

No major impacts to agriculture, forestry, wildlife, recreation or socio-economic resources are expected along this route segment.


TANZILLA
STIKINE CANYON
STIKINE COLLECTOR
RUPERT



B.C. HYDRO

FIGURE 7-1

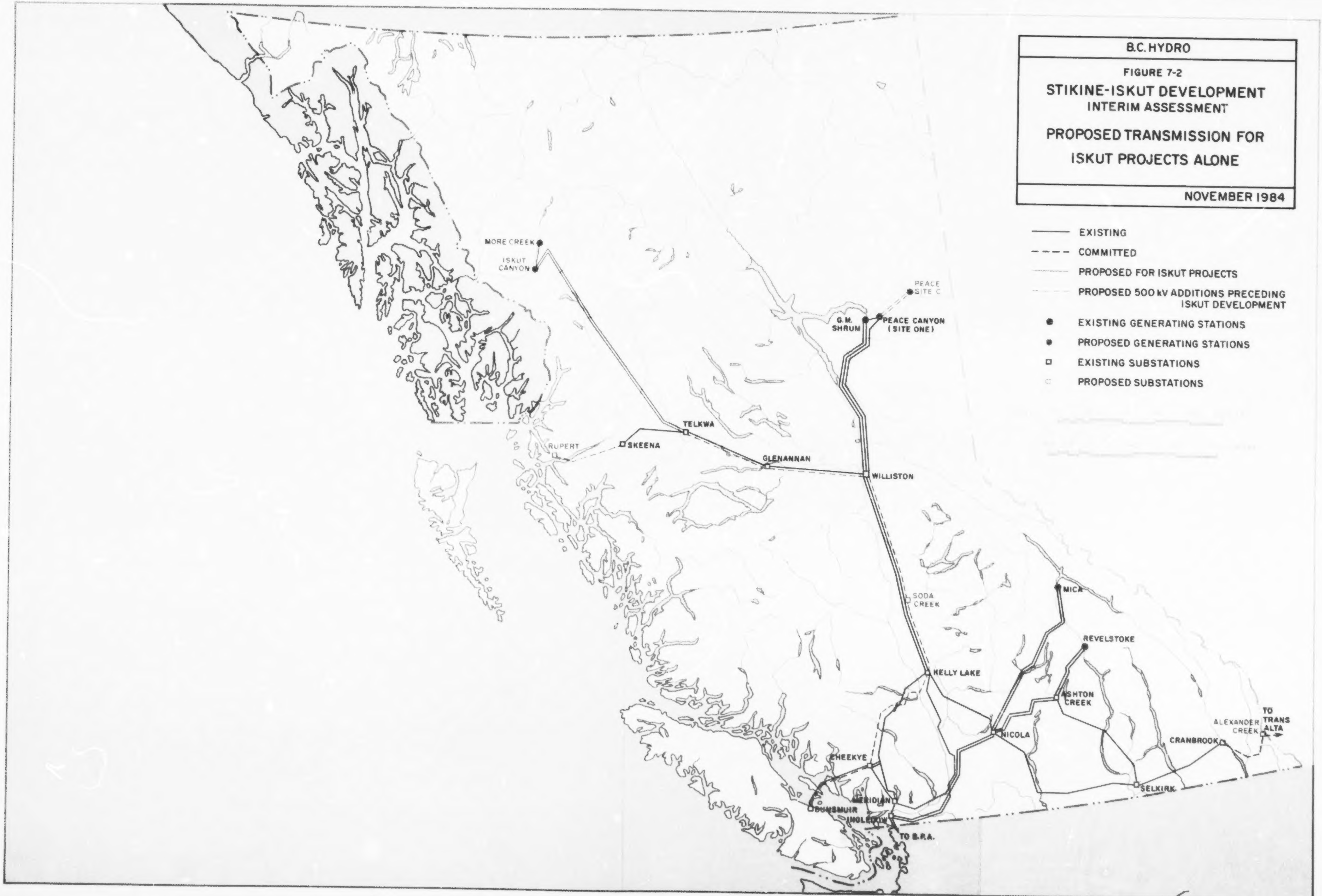
STIKINE-ISKUT DEVELOPMENT
INTERIM ASSESSMENT

PROPOSED TRANSMISSION AND
PROJECTED SYSTEM REINFORCEMENT
FOR STIKINE PROJECTS ALONE

NOVEMBER 1984

— EXISTING
- - - - COMMITTED
═ PROPOSED FOR STIKINE PROJECTS
═ PROPOSED 500 kV ADDITIONS PRECEDING STIKINE DEVELOPMENT
● EXISTING GENERATING STATIONS
● PROPOSED GENERATING STATIONS
□ EXISTING SUBSTATIONS
□ PROPOSED SUBSTATIONS

PEACE SITE C
G.M. SHRUM
PEACE CANYON (SITE ONE)
TELKWA
KEENA
GLENANNAN
WILLISTON
SODA CREEK
MICA
REVELSTOKE
DASH CREEK
KELLY LAKE
ASHTON CREEK
NICOLA
ALEXANDER CREEK
TO TRANS ALTA
CRANBROOK
CHEEKYE
SELKIRK
MERIDIAN
DUNSMUIR
INGLEDOW
TO B.P.A.


MORE CREEK
ISKUT CANYON
PEACE SITE C
G.M. SHRUM
PEACE CANYON (SITE ONE)
TELKWA
RUPERT
SKEENA
GLENANNAN
WILLISTON
SODA CREEK
MICA
REVELSTOKE
KELLY LAKE
ASHTON CREEK
NICOLA
ALEXANDER CREEK
TO TRANS ALTA
CRANBROOK
SELKIRK
CHEEKYE
MERIDIAN
DUNSMUIR
INGLEDOW
TO B.P.A.

B.C. HYDRO

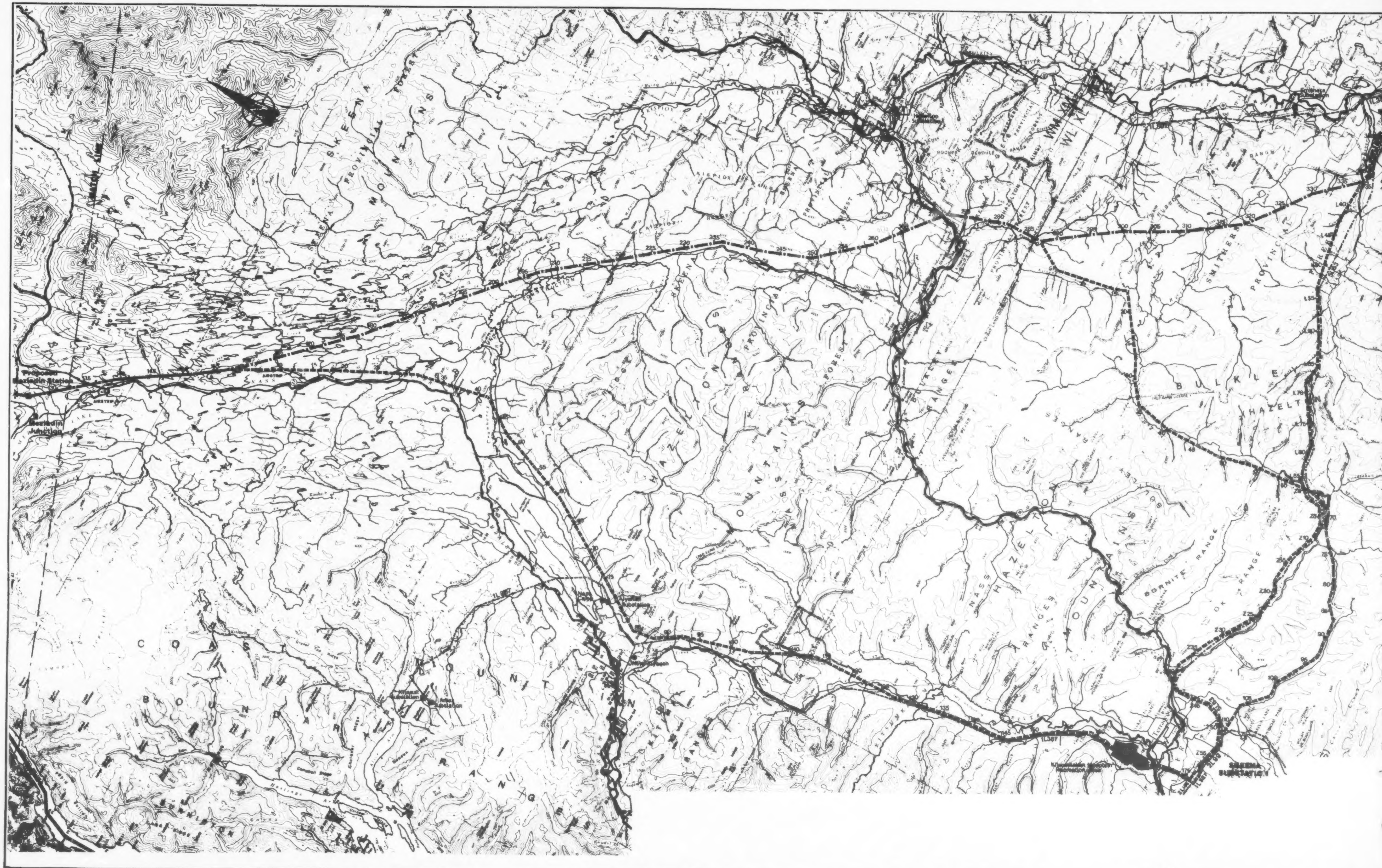
FIGURE 7-2

STIKINE-ISKUT DEVELOPMENT
INTERIM ASSESSMENT

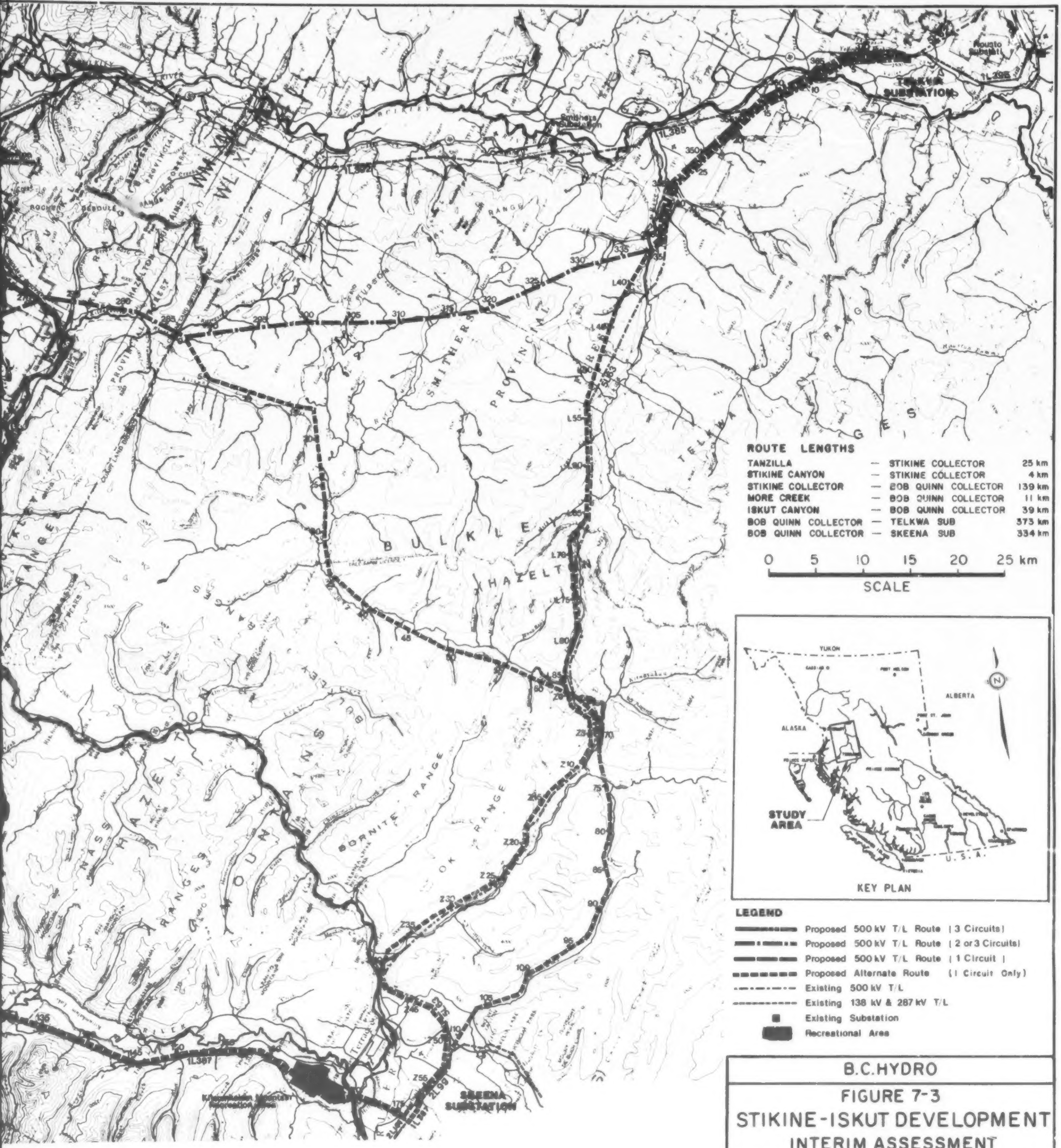
PROPOSED TRANSMISSION FOR
ISKUT PROJECTS ALONE

NOVEMBER 1984

EXISTING
COMMITTED
PROPOSED FOR ISKUT PROJECTS
PROPOSED 500 kV ADDITIONS PRECEDING ISKUT DEVELOPMENT
EXISTING GENERATING STATIONS
PROPOSED GENERATING STATIONS
EXISTING SUBSTATIONS
PROPOSED SUBSTATIONS



Proposed Meziadin Station
Meziadin Junction
AIRSTRIP
135
145
SKEENA MOUNTAINS
PROVINCIAL FOREST
COAST MOUNTAINS
BOUNDARY RANGES
NASS RANGES
HAZELTON MOUNTAINS
BULKLEY
SMITHERS
BORNITE RANGE
Terrace
1L387
2L99
SKEENA SUBSTATION


TELKWA SUBSTATION
Smithers Substation
BULKLEY
HAZELTON
SMITHERS PROVINCIAL
TELKWA
BORNITE RANGE
NASS
HAZELTON MOUNTAINS
BULKLEY RANGES
SKEENA SUBSTATION
1L387
1L385
KEY PLAN
YUKON
ALBERTA
ALASKA
STUDY AREA
U.S.A.
SCALE
0 5 10 15 20 25 km

ROUTE LENGTHS

TANZILLA	— STIKINE COLLECTOR	25 km
STIKINE CANYON	— STIKINE COLLECTOR	4 km
STIKINE COLLECTOR	— BOB QUINN COLLECTOR	139 km
MORE CREEK	— BOB QUINN COLLECTOR	11 km
ISKUT CANYON	— BOB QUINN COLLECTOR	39 km
BOB QUINN COLLECTOR	— TELKWA SUB	373 km
BOB QUINN COLLECTOR	— SKEENA SUB	334 km

LEGEND

- Proposed 500 kV T/L Route (3 Circuits)
- Proposed 500 kV T/L Route (2 or 3 Circuits)
- Proposed 500 kV T/L Route (1 Circuit)
- Proposed Alternate Route (1 Circuit Only)
- Existing 500 kV T/L
- Existing 138 kV & 287 kV T/L
- ■ Existing Substation
- Recreational Area

B.C.HYDRO

FIGURE 7-3

STIKINE-ISKUT DEVELOPMENT
INTERIM ASSESSMENT
ALTERNATE TRANSMISSION
LINE ROUTES TO
SKEENA SUBSTATION

NOVEMBER 1984

TABLE 7-1

COSTS OF PARTIAL DEVELOPMENT

	Costs in 1984 $Million					Capacity	Firm Energy	Secondary Energy
	Generation	Transmission	Total	System Reinforcement	Total	MW	GWh	GWh
Total Development	5188	821	6009	314	6323	2900	13120	2240
Stikine Projects Only	3452	623	4075	241	4316	1920	9070	1910
Iskut Projects Only	1736	376	2112	-	2112	980	4050	330

SECTION 8.0 - FURTHER STUDIES

8.1 GENERAL

Application for an Energy Project Certificate for the Stikine-Iskut Development would be required ten years prior to the in-service date of the first project. Environmental and hydrological monitoring would need to resume six years before the application. Five years before the application discussions with the public regarding the selection of transmission line corridors for detailed route selection studies would be initiated. Approximately three years before the application, study terms of reference and requests for proposals for drilling and other field-oriented studies would be prepared. Environmental and engineering field studies would commence in the spring of the following year and would require two summer field seasons. On completion of the second field season work would focus on documentation of the studies and preparation of an application for the fall of the next year. Consultation with the public would be on-going up to the application.

8.2 GENERATION STUDIES

8.2.1 ENGINEERING

a) General

Two summer exploration seasons and one year of office studies would be required to finalize the selection of the optimum project arrangement and thus complete Phase I. Report No. 1674 "Stikine-Iskut Development Iskut Canyon and More Creek projects - Preliminary Design Study - Phase I - Interim Report" and a similar report (No. 1718) for the Stikine River Projects identified a number of studies that should be initiated immediately upon resumption of preliminary design as they could have a major effect on the project arrangements chosen.

b) Stikine River Projects

A 2-year geotechnical exploration program should be carried out at the Stikine Canyon Project site and at the Tanzilla damsite to help identification of an optimum dam type and arrangement. This program will include geological mapping, surveys, drilling and adit excavation and development of 3-dimensional geological models. For the Tanzilla damsite, assessment of the age and nature of the faults and an assessment of the area seismicity will be required as they may affect the general arrangement of the project.

Reservoir shoreline studies have identified areas in both reservoirs where impoundment and fluctuations of the water levels could cause sliding or slumping. Further site investigations in these areas will be required to define the risk to the projects. Further field investigations, involving drilling, test pitting and geological mapping will be required to optimize the various construction material sources.

A number of office studies will be required to complete Phase I of the preliminary design. These include optimization studies to define the installation capacities, drawdown and the maximum normal reservoir levels. Flood frequency and the probable maximum flood studies will have to be updated based on information collected during the deferment of the studies.

In addition, studies evaluating different project structures or design features that could be practically used will have to be completed before a final project arrangement could be decided on. These would include, but not be limited to, studies of various types of dams, underground and surface powerhouses, energy dissipation for flow releases from the various spillway and outlet facilities, etc. Also included would be a review of the operation of the powerplants.

c) Iskut Basin Projects

Exploration carried out in 1983 indicated that at least 4 periods of volcanic activity (8700, 6500, 5400 and 3000 years ago) occurred in the lava flats region in the last 10,000 years. In addition, some evidence exists to suggest that a volcanic eruption occurred as late as 1000 years ago. A seismic and volcanic assessment of the project areas including a risk analysis is therefore a top priority. Field investigations necessary to gather information for these studies would include geologic mapping, surveys and test pits.

As part of the seismic assessment, the possibility of differential movement along shears in the foundation rock in the C reach would have to be determined as this could decide the dam type in the main canyon. Regional geologic site geological mapping would be required for this assessment.

Seepage around the Iskut Canyon damsite through the lava flows needs further assessment. These studies would, among other things, entail more drilling, permeability testing and geologic mapping.

At the More Creek & Forrest Kerr Creek damsites only limited site exploration has been carried out. At More Creek, it appears that the rock foundations would be suitable for any dam type; however, additional exploration, including geological mapping, surveys and drilling would be required. More site investigation at the Forrest Kerr diversion damsite would also be required.

Reservoir shoreline studies have identified locations in both project areas where reservoir impoundment and operation could cause sliding or slumping. Further site investigations in the areas are required to define the risk to the projects.

A number of office studies would be required to complete Phase I. These include optimization studies to define the installed capacity, drawdown and the maximum normal reservoir elevation. Studies would be required to evaluate the seepage loss from the Iskut Canyon reservoir. Flood frequency and the Probable Maximum Flood studies would have to be updated based on information that will be collected during the project deferment period. Similarly, seismic studies to assess the results of the micro-seismic monitoring would be required. In addition, a number of other dam studies, each evaluating different project structures or design features that could be practically used would have to be completed before a final project arrangement could be decided upon.

8.2.2 ENVIRONMENTAL

Detailed environmental impact assessment studies for the generation component were nearing completion in most discipline areas at the time of study deferral. While most major impacts have been identified, there remains a need to study some of the subject areas in greater detail.

A list of potential further studies for the generation component is given in Table 8.1. Decisions will be made when the proposed development is reactivated to undertake those studies which are likely to result in the best assessment of development impacts in a cost-effective manner.

8.2.3 INTERACTIVE STUDIES

In concluding future engineering and environmental studies it is important that the interaction between the two studies as described in Section 2.1.6 be continued. This interaction is required to ensure the optimum development.

8.3 TRANSMISSION STUDIES

8.3.1 ENGINEERING

When studies resume, a complete re-evaluation of the transmission system requirements with the current load forecast and generation development plans will be required. This re-evaluation would establish which transmission options for connecting the Stikine-Iskut generation sites to the electric grid and for reinforcing the system to the south require examination. It is expected that the two options presented in this Interim Assessment Report for connection to the electric grid would not change (ie. three lines to Telkwa or one line to Skeena, two lines to Telkwa). However system reinforcement requirements could differ substantially from those currently projected.

Prior to commencing detailed route selection studies, potential transmission line corridors would be examined in light of previously documented studies, developments that have occurred in the area during the study deferral period, and the current system requirements. A corridor would be selected for detailed study based on this information and input from the public and government agencies.

If the corridor selected is the same as that considered in this Interim Assessment Report for the proposed development or development alternatives, then detailed studies would continue from the present level of information. If the corridor selected is different, a preliminary technical route would have to be established within the new corridor. In either case engineering work would include taking low level aerial photography over much of the selected corridor (1:25,000 scale), conducting feasibility surveys of technically difficult areas within the corridors (ie. Ningunsaw Pass, Iskut Canyon, Telkwa River Crossing), and interacting with the environmental studies' group toward optimizing the technically preferred route. It is assumed that centreline survey, leading to specific determination of the route alignment, would be conducted following development approval.

8.3.2 ENVIRONMENTAL

The route evaluated for this interim report has not been optimized from either the engineering or environmental points of view. Once the project is reactivated, the process of integrated engineering/environmental route selection will require completion. For some environmental disciplines, much of the proposed work for the detailed study phase was completed before deferment and/or as part of the work done for the interim report. Other disciplines have very little information beyond that collected in the preliminary studies. Table 8.1 provides a brief description of proposed future studies for the transmission system. Socio-economic studies would be integrated with the generation component.

8.4 APPLICATION

Specific Documentation is required for an application for an Energy Project Certificate. This includes a description of the proposed development and an assessment of environmental and socio-economic impacts together with a mitigation plan. These will be prepared from the engineering and environmental studies completed prior to the application.

In addition, documentation setting out the justification for development will be required. This will include information on energy supply and demand, technical feasibility, financial feasibility and procurement policy. A cost benefit analysis and a cost of service analysis will also be required. It is foreseen that these studies will be undertaken shortly before an application for an Energy Project Certificate is submitted. Terms of Reference for these studies would be agreed with the Energy Project Coordinating Committee.

TABLE 8-1

STIKINE-ISKUT HYDROELECTRIC DEVELOPMENT
RECOMMENDED FURTHER STUDIES

Study Area		
Generation Component		
1. Climate	a.	Undertake a study to determine the effects of reservoirs on the local climate, especially in populated areas such as Telegraph Creek.
2. Soils/Surficial Geology/Geology	a.	Detailed (1:10 000 scale) terrain inventories are required in major construction areas.
	b.	A site reclamation plan indicating materials handling and scheduling should be prepared.
	c.	Revegetation trials should be carried out to confirm effective site-specific reclamation methods.
	d.	The importance of the Stikine River water levels to maintenance of groundwater recharge in low-lying terraces near the Chutine River require study.
	e.	Information on potential effects of the development on economic geology require updating.
3. Vegetation	a.	Reassess amounts and types of vegetation impacted by reservoirs (if new water levels are determined).
4. Agriculture	a.	Complete and update detailed agricultural land assessment: - further evaluation of agricultural land capability in Stikine Canyon reservoir area: - reassess economics of potential agricultural development.
5. Forestry	a.	Update forest inventory data and complete new analysis of development effects on relevant Timber Supply Areas.
	b.	Further economic analysis of value of timber to input to mitigation/compensation programs.

6. **Hydrology**

a. Investigate relationship between water temperatures in the main channel and adjacent secondary channels utilized by rearing fish. Document the natural variability of water temperatures in secondary channels and estimate the expected changes in water temperature following regulation. Since such an investigation could not include the entire river, the Lower Stikine Test Reach would provide a suitable location.

b. Investigate the hydraulic characteristics of the Stikine-Tahltan confluence to assess the effects of low mainstem discharge upon fish access into the Tahltan River. Three cross-sections should be established below the confluence so that backwater profiles can be computed from which water levels at the Tahltan mouth can be estimated. The survey should also include a bed profile of the mouth of the Tahltan River extending into the Stikine River.

c. Document distribution and characteristics (temperature, area, substrate, aquatic organisms etc) of groundwater discharge on the Stikine and Iskut floodplain. A sequence of overlays showing areas of groundwater upwelling, areas which tend to remain ice free during the winter and areas where fish have been observed to spawn would help assess the role groundwater plays in the life stages of salmon. Information from such a study may provide direction for studies of overwintering juveniles.

d. Document the hydrological conditions which lead to the stranding and mortality of juvenile fish on the Stikine and Iskut rivers. The study should attempt to answer whether there is a range of flows from which stranding is particularly frequent due to channel morphology and whether a critical rate of change in stage/discharge can be identified in the spring and summer which causes stranding.

e. Undertake a study in representative reaches to document the extend of suitable spawning areas and assess the proportion which may be affected by morphological changes due to regulation.

f. Based upon hydrological data obtained in 1983 and supplemented with data obtained during the monitoring program, determine the area of the flood plain in the Darsmith and Estuary test reaches which is subject to flooding for different return periods under natural and regulated conditions. The study should also include an investigation of the relationship between water levels in the Stikine River and standing water in marsh and wetland areas of the floodplain. This would be used to assess the effects of reduced summer mainstem water levels on possible changes in vegetation succession.

g. Demonstrate that the reservoir model 'MANAGER' accurately simulates conditions in northern reservoirs. Once the validity of the model is demonstrated, modelling of the Stikine and Iskut reservoirs should be updated as hydrometeorological data becomes available.

h. Obtain more refined predictions, if possible, of the probable and worst case changes which could occur in the morphology of the Stikine estuary following regulation of the Stikine and Iskut rivers.

i. A preliminary monitoring program for the lower reaches covering two consecutive years should be conducted. The results from this program would be used to develop a detailed program over the next 2 year period which would also include the upper reaches. Ideally, there should be no interruption in the program so that a continuous data base over 4 years would result. The program should encompass physical, chemical and biological parameters as well as geochemical analysis of sediments.

j. In conjunction with the water quality monitoring programs, an in depth study of the transport of nutrients and suspended sediment from the Stikine River to its estuary should be carried out over an annual cycle. The significance of this study would be in maintaining existing fish stocks which inhabit the estuary during a critical portion of their life cycle.

Once a comprehensive data base has been achieved, further runs of the numerical model should be provided to simulate with improved confidence, future water quality.

k. A comprehensive program should be conducted to evaluate the potential for gas supersaturation effects on fish downstream of the proposed structures. The program should include sampling in potential release locations to determine background levels prior to any development.

7. Fisheries

a. Develop physical models to relate flow regulation effects on amount and distribution of fish habitat.

b. Develop studies to relate fish habitat abundance and quality to actual fish abundance.

c. Determine to what extent chinook salmon utilize the Stikine and Iskut mainstems for spawning.

d. Locate overwintering habitat for juvenile fish and determine the effects of flow regulation.

e. Determine the effect of lowered spring flows and reduced incidence of spring floods on coho migration and rearing using a mark-recapture technique.

f. Determine the effect of regulation on the timing and location of spawning fish.

g. Evaluate the role of river discharge, temperature and tides in determining the timing and distribution of eulachon spawning; collect data on rate of development of eulachon and how regulation changes on water temperature and discharge will affect larval dispersal in the estuary.

h. Examine the relationship between river discharge and estuarine plankton productivity.

i. Evaluate the effects of river discharge on salinity penetration into the estuary and floodplain; major changes in salinity may effect distribution of starry flounder and outmigrations of salmon, particularly pink and coho fry.

8. Wildlife

a. Survey aquatic, wetland, and floodplain wildlife populations along the Stikine and Iskut rivers below the Tanzilla and Iskut Canyon dams. Additional information is needed on impacts on water quantity and quality, alluvial substrates, aquatic food chain, ice cover and plant succession to assess secondary impacts on wildlife.

b. Conduct wildlife inventories to collect information on:

    - Seasonal mountain goat data for the Iskut basin, in particular the More Creek and Iskut Canyon damsites and vicinity.

		- Caribou inventory information for the Hotailuh Range-northern Klastline Plateau area, including the Stikine River crossing west of Highway 37. - Grizzly bear use of alluvial habitats in the eastern part of the Stikine Canyon reservoir, and in the upper More Creek-Forrest Kerr Divide area. - Undertake long-term wildlife monitoring to determine how representative the existing data base is.
9. Recreation/Tourism	a.	Evaluate an additional recreation/tourism scenario for comparative purposes that assumes considerable expansion in commercial and public recreation facilities.
	b.	Develop more detail on the carrying capacity of existing recreation and tourism resources.
	c.	Update all inventory relating to recreation use.
10. Visual	a.	Undertake visual impact studies for Iskut and More Creek reservoirs.
11. Heritage	a.	Undertake evaluative testing at sites within the reservoir breakline areas and within borrow pit areas.
12. Land Use	a.	Update land use inventory and integrate information into final mitigated development description.
13. Socio-economics	a.	When studies are reactivated, develop a dialoge with communities in the area to discuss implications of the development (duration approximately 18 months).
	b.	Conduct a detailed socio-economic study of both generation and transmission areas (duration approximately 12 months).
14. Settlement	a.	Further studies are anticipated approximately two years before the eventual date for application for an Energy Project Certificate. Over an 18-month period the various settlement options should be reviewed with others affected, i.e. with the local communities, government and local employers including any potential resource industries. This should be concurrent with socio-economic and community consultation dialogue regarding development

			implcations. The purpose of the review will be to select and describe a firm preference which will then constitue the core of the Conceptual Settlement Plan. A minimum of six months is required for finalization of the plan after the public review period.
15.	Resource Evaluation	a.	Update all economic data and recalculate net costs of environmental resources foregone by the proposed development.
		b.	Incorporate data from transmission and off-site components of the development.
16.	Mitigation/Compensation	a.	Develop a detailed mitigation/compensation plan with input from public and government agencies.

Transmission Component*

1.	Terrain	a.	The locations of mineral deposits and mining claims would be assembled. Areas of specific terrain concern are mostly known. These would be examined further to determine hazard potential and mitigation measures.
2.	Agriculture	a.	The majority of the inventory information is presently available but could quickly become out-of-date. The agriculture data based would therefore be updated to account for changes in production and economic potential that have occurred during the period of deferral. Site-specific evaluation of properties affected, notably in the Telkwa area, have not been undertaken as yet; these would also require completion.
3.	Forestry	a.	The work would concentrate on determining the locations of best forest sites and the areas where highest volume stands are present.
4.	Fisheries	a.	Inventory data on the locations of rivers and streams important to anadromous fish have been compiled. Further information on resident fish in lakes to determine the level and importance of food fisheries would be required for impact assessment purposes.
5.	Wildlife	a.	Most of the studies suggested in the original terms of reference have been completed. However, hunting and guiding harvest data would need to be compiled and interviews with local wildlife users completed.

			An aerial survey to determine 'critical' winter habitat is planned on a contingency basis if/when a winter with a particularly high snow pack occurs. In the summer following this survey, complementary ground checking of critical ungulate range used during winter would be completed.
6.	Recreation	a.	An inventory of existing recreational facilities has been collected. This would require updating when studies resume. In addition, an inventory of present and potential future use would be needed to assess the impacts that would occur with the transmission line.
7.	Visual	a.	The present work was directed towards assessment of a given route. Completion of viewshed mapping, i.e. locations within the corridor where transmission lines would be visible from the highway and the site viewing areas, would be required to provide input to routing decisions. Mitigation measures would be sought to further limit visibility and to ensure that new facilities are located to maximize benefits to visual resource use.

SECTION 9.0 - CONCLUSIONS

9.1 OPTIMUM POWER DEVELOPMENT

9.1.1 GENERATION

Studies undertaken to date indicate that the optimum power development on the Stikine and Iskut rivers would consist of four generation projects as follows.

River	Project	Powerplant Capacity MW	Dam Height Metres	Reservoir Area Hectares
Stikine	Stikine Canyon	960	270	12600
Stikine	Tanzilla	960	193	850
Iskut	Iskut Canyon	810	175	3700
More Creek	More Creek*	170	145	4300
	Total Capacity	2900		

* Includes Forrest Kerr Creek Diversion.

Sufficient engineering investigations and analysis have been completed to establish that dams of the heights proposed at each project site would be technically feasible. However more investigations and studies are required to confirm the type of dam best suited to each site.

Preliminary designs for several types of dams for each of the projects have been prepared and one layout for each project is featured. The layout featured is either the layout which is expected to be the most economic or that which is most conservative based on current knowledge of the site foundations.

The studies should specifically address the following key unknowns identified in the work completed to date.

1. The risk and potential effect of renewed volcanic activity in the area adjacent to the Iskut Canyon site.

2. The potential for seismic activity in the Iskut Canyon are (possibly reservoir triggered) and the risk of differential movement along shears in the foundation rock.

3. The amount of seepage losses expected and the extent of seepage control measures required under the lava flats area at Iskut Canyon.

4. The extent and nature of sliding and slumping that could occur in identified areas along each of the proposed reservoirs which would appear to be susceptible to instability.

In addition to the above number of years of further hydrological and climatological data are required to enable defensible estimates to be made of the probable maximum flood for each project.

An Engineering Advisory Board for the Stikine and Iskut generation projects was appointed in 1981. The Board met on three occasions the last of which was in September 1983. At that time the Board reviewed the results of all investigations and the current preliminary designs for each project and generally concurred with the engineering work completed to date, and future work required.

9.1.2 TRANSMISSION

The optimum system for transmitting electrical energy from the Stikine-Iskut generation sites to the existing electric grid would be three 500 kV lines to the Telkwa substation near Smithers generally following a route close to Highway 37. Power from each of the generating stations would first be connected to collector stations via 500 kV and 230 kV lines before being transmitted south to the existing grid.

Transmission route selection studies have only proceeded to the stage where a preferred corridor has been selected and agreed to by the Energy Project Coordinating Committee and a preliminary route identified within that corridor. This route cannot be finalized until detailed engineering and environmental studies have been completed and reviewed by the public and government agencies.

No unusual engineering problems are expected in constructing and maintaining the transmission lines along the proposed preliminary route with the exception of that portion in the Ningunsaw Pass. The Ningunsaw valley at this location is very narrow and contains Highway 37 and an ecological reserve. Snow avalanches are common. Detailed engineering study is required to locate a technically acceptable route and line configuration through this confined and hazardous area.

9.2 COSTS AND BENEFITS

9.2.1 CAPITAL COSTS

The estimated capital costs of each of the projects and the total development are as follows. The costs are in October 1984 $ Million and allowances are shown for corporate overhead.

	Direct Cost	Overhead	Total
Generation	4759	429	5188
Transmission	673	60	733
Development Total	5432	489	5921
System Reinforcement	339	30	369
Total	5771	519	6290

9.2.2 POWER BENEFITS

The estimated firm and secondary energy benefits and capacity benefits for the total development are as follows. These values were determined by simulations of the total projected electric system, including Peace Site C, Keenleyside and Murphy Creek, with and without the Stikine-Iskut development.

Annual firm energy	-	13120 GWh
Av. Annual secondary energy	-	2240 GWh
Dependable capacity	-	2810 MW

9.2.3 VALUE AND COST OF BENEFITS

Using the latest values for energy and capacity (1983) the Stikine-Iskut development would have a benefit to cost ratio of 1.14. Energy values are determined as the average cost of energy of the projects being considered for future development including the Stikine-Iskut development and alternatives to the Stikine-Iskut. Averages are taken of three sequences of alternative project and the full range of probable load forecast.

The estimated unit cost of firm energy in 1983 dollars is 19.1 mills/kWh at a discount rate of 4% exclusive of taxes.

9.3 ENVIRONMENTAL AND SOCIO-ECONOMIC IMPACTS

9.3.1 GENERAL

Detailed environmental studies for the generation projects have been underway since 1978. Preliminary environmental studies of the several possible transmission corridors also commenced in 1978 and were completed in 1982. The environmental studies included the following components:

Climate and Air Quality
Terrain and Geological Resources
Vegetation
Agriculture

Forestry
Water Resources
Aquatic Resources
Wildlife
Recreation
Visual Resources
Heritage
Land Use
Socio-Economic studies
Settlement Studies
Resource Evaluation

Assessments of the impacts from all of these study components for both the generation and transmission projects are contained in the IAR. The following covers only the major potential impacts of the development identified in these assessments.

9.3.2 AQUATIC RESOURCES

The Stikine and Iskut rivers support small but important runs of all five species of Pacific salmon as well as Steelhead trout. These fish are caught commercially primarily by Alaskan fishermen although a small commercial fishery has recently been developed in the Canadian section of the lower Stikine River. The commercial catch of Stikine salmon has declined significantly in recent years, particularly catches of chinook and coho.

The effects of the development on fish habitat are in many cases complex and hence difficult to predict. In addition, basic knowledge of Stikine fisheries is insufficient to allow precise prediction of the effects of changes in habitat or even in some cases whether such changes would be positive or negative. Major impacts on fisheries resources could result from:

1. a more stabilized seasonal flow regime which in the long term would reduce the extent of river secondary channels and lower summer water levels. These changes would reduce the amount of salmon fry rearing habitat and sockeye spawning habitat;

2. short term fluctuations in river discharge resulting from hourly, daily and weekly changes in power demand. These fluctuations could interrupt mainstem spawning, expose redds and strand fish.

3. seasonal changes in river water temperatures downstream of the proposed projects due to the storage of water in the reservoirs. Warmer winter temperatures could affect egg incubation rates and hence fry survival. Colder summer temperatures could affect fry growth rates.

Although our knowledge of these impacts needs to be improved, it can be stated that all aquatic impacts can either be mitigated by altering project design and operation or can be compensated for by developing alternative habitat.

9.3.3 WILDLIFE RESOURCES

The major impact on wildlife resources in the project areas would be the flooding of 17,000 ha of habitat by the proposed reservoirs. This loss cannot be avoided if the development proceeds and represents loss of habitat for 120 moose, 55 goats, 80 bears and numerous furbearers and birds.

Impacts on wildlife may also occur indirectly due to changes in vegetation succession downstream of the proposed projects and in the estuary tidal marshes. More study is required to fully assess these potential impacts.

Other wildlife impacts could result from transmission line clearing, new access into wilderness areas and increased hunting pressures. These impacts can be mitigated, by careful transmission route location, access road design and control, and hunting restrictions. controls.

9.3.4 RECREATION & VISUAL RESOURCES

Two major impacts on recreation and visual resources would result from:

1. the partial flooding of the upper 15 km of the Grand Canyon of the Stikine which is considered to be a major national feature.

2. the construction of transmission lines following near to the route of Highway 37 which is designated as a "wilderness highway".

These impacts can only be partially compensated by providing access into previously inaccessible areas for recreation and viewing and by carefully locating and screening transmission lines.

9.3.5 SOCIAL

Major social impacts could result from the development because the projects are large, would require a large influx of construction workers, and are located in an isolated northern areas with a very small population and mainly subsistence lifestyles. The main issues that must be addressed prior to development are:

1. relations with Native Indians
2. protection of subsistence lifestyle
3. local employment and business opportunities
4. disturbances such as traffic, noise, dust, etc.
5. provision of adequate local services

9.4 DEVELOPMENT ALTERNATIVES

The Iskut projects could be constructed without the Stikine projects thus developing only 980 MW or 1/3 of the total proposed development. The unit cost of energy from the Iskut projects alone including the cost of transmission would be about 25% more than the unit cost of energy from the total development.

Development of the Iskut projects along would result in considerably less environmental and social impacts because:

1. the Stikine River above the Iskut confluence would be unaffected and this section of the river contains the majority of salmon habitat.

2. the flow changes in the estuary would be reduced to about 1/2 of that for the total development.

3. the Grand Canyon of the Stikine would not be affected.

4. the land flooded by reservoirs would be about 1/3 of that for the total development.

5. the local communities of Telegraph Creek, Dease Lake and Iskut would be largely unaffected.

The two Stikine projects could be developed alone (1920 MW or 2/3 the total development) and the unit cost of energy would be about the same as that for the total development. However, this development would retain most the major environmental and social impacts of the total development.

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APPENDIX A

REPORTS PREPARED BY AND FOR B.C. HYDRO

GENERATION

ENGINEERING

Reports prepared by B.C. Hydro

1. HGPD, (In draft). Stikine-Iskut Development - Iskut Canyon and More Creek Projects - Reservoir Shoreline Study. HGPD Report No. H1681.

2. HGPD, (In draft). Tanzilla and Stikine Canyon Projects - Reservoir Shoreline Study. Report No. H1699.

3. HGPD, (In draft). Iskut Canyon and More Creek Projects - 1982/83 Geotechnical Investigation. Report No. H1614.

4. HGPD, November 1984. Iskut Canyon-More Creek Projects. Hydraulic Design Memorandum. Report No. H1777.

5. HGPD, November 1984. Stikine River Development - Physical Habitat Assessment for Juvenile Chinook - Lower Stikine Test Reach. Report No. H1739.

6. HGPD, November 1984. Stikine-Iskut Development - Downstream Water Temperature Study. Report No. H1700.

7. HGPD, November 1984. Stikine-Iskut Development - Interim Preliminary Design, Natural and Regulated Flow Regimes. Report No. H1680.

8. HGPD, November 1984. Stikine-Iskut Development - Iskut Canyon and More Creek Generation Projects - Interim Preliminary Design Report. Report No. H1674.

9. HGPD, November 1984. Stikine Canyon Project - 1981 to 1983 Geotechnical Investigations. Report No. H1479.

10. HGPD, October 1984. Stikine Canyon and Tanzilla Projects - Hydraulic Design Memorandum. Report No. H1736.

11. HGPD, October 1984. Stikine River Projects - Interim Preliminary Design, Probable Maximum Floods at Stikine Canyon and Tanzilla Sites. Report No. H1685.

12. HGPD, September 1984. Stikine Canyon Project and Tanzilla Project - Memorandum on Design of the Concrete Arch and Embankment Dams. Report No. H1774.

13. HGPD, August 1984. Iskut Canyon and More Creek Projects - Preliminary Design Study, Phase 1 Interim Report. Report No. H1674.

14. HGPD, August 1984. Tanzilla Projects - 1982/83 Geotechnical Investigation. Report No. H1590.

15. HGPD, May 1984. Stikine-Iskut Development - Report on Stage I Settlement Studies. Report No. H1544.

16. HGPD, March 1984. Stikine River Projects - Memorandum on 1982/82 Construction Materials Investigations. Report No. GEO 6/83.

17. HGPD, November 1983. Iskut Canyon and More Creek Projects - Memorandum on 1982/83 Construction Materials Investigations. Report No. GEO 18/82.

18. HGPD, November 1983. Stikine-Iskut Development - Hydrology, River Regime and Morphology Addendum Report on Ice Observations. Report No. H1606.

19. HGPD, October 1983. Stikine-Iskut Development - Interim Preliminary Design, Reservoir Sedimentation and Syspended Sediment Balance. Report No. H1664.

20. HGPD, September 1983. Stikine-Iskut Development - Iskut Projects - Summary of Information for Advisory Board Meeting No. 3. Report No. H1648.

21. HGPD, September 1983. Stikine River Projects - Summary of Information for Advisory Board Meeting No. 3. Report No. H1646.

22. HGPD, May 1983. Stikine Canyon Project - Memorandum on 1981 Construction Materials Investigation. Report No. GEO 1/83.

23. HGPD, January 1983. Stikine-Iskut Hydroelectric Development - Interim Report on Water Temperature Studies, Selection of a Water Temperature Model and Expansion of the Data Collection Program. Report No. H1610.

24. HGPD, December 1982. Stikine-Iskut Development - Hydrology, River Regime and Morphology, Addendum Report on Syspended Sediment. Report No. H1406.

25. HGPD, December 1982. Stikine-Iskut Development - Hydrology, River Regime and Morphology, Addendum Report on Water Temperature. Report No. H1406.

26. HGPD, November 1982. Stikine-Iskut Development - Hydrology, River Regime and Morphology, Addendum Report on Test Reaches. Report No. H1581.

27. HGPD, August 1982. Tanzilla Project - Memorandum on Alternative Project Layouts for Advisory Board Meeting No. 2. Report No. H1557.

28. HGPD, August 1982. Stikine-Iskut Development - Iskut Projects - Summary of Information for Advisory Board Meeting No. 2. Report No. H1548.

29. HGPD, August 1982. Stikine River Projects - Summary of Information for Advisory Board Meeting No. 2. Report No. H1546.

30. HGPD, August 1982. Iskut Canyon and More Creek Projects - Feasibility Study, 1981 Geotechnical Investigations. Report No. H1496.

31. HGPD, May 1982. Tanzilla Project - 1981 Geotechnical Investigations. Report No. H1477.

32. HGPD, December 1981. Stikine-Iskut Development - Site Z/Tanzilla Projects-1980 Geotechnical Investigations. Report No. H1314.

33. HGPD, October 1981. Stikine-Iskut Feasibility Study - Hydrology, River Regime and Morphology. Report No. H1110.

34. HGPD, August 1981. Stikine-Iskut Development - Summary of Information for Advisory Board Meeting No. 1. Report No. H1400.

35. HGPD, March 1981. Iskut River Development - Iskut Canyon Project - Memorandum on Site Access Alternatives. Report No. H1355.

36. HGPD, January 1981. Iskut River-More Creek - Feasibility. 1980 Geotechnical Investigation. Report No. H1331.

37. HGPD, April 1980. Iskut River-More Creek Feasibility Study - 1979 Geotechnical Investigations. Report No. H1228.

38. HGPD, October 1980. Stikine River Hydroelectric Development - Feasibility Study. 1979 Geotechnical Investigations. Report No. H1166.

39. HGPD, March 1980. Stikine-Iskut Hydroelectric Development - Feasibility Study. Report No. H1163.

40. HEDD, June 1979. Stikine-Iskut Rivers - Hydroelectric Development Feasibility Study - 1978 Geotechnical Investigations. Report No. H991.

41. HGPD, March 1978. Iskut Development Project - Overview Study, Hydrology. Report No. DD109.

42. HEDD, January 1978. Hydroelectric Development of the Stikine River - Overview Study. Report No. 889.

43. HEDD, January 1978. Hydroelectric Development of the Iskut River - Overview Study. Report No. 890.

44. HEDD, September 1977. Stikine Development Project - Overview Study, Hydrology. Report No. DD102.

45. IPEC, February 1966. Interim Report on Hydroelectric Potential of the Iskut and Stikine Rivers.

Reports prepared for B.C. Hydro

46. Access Geological Services, September 1983. Mapping Program in the Iskut Canyon, Purchase Order No. 346 000.

47. Ager, Berretta and Associates, December 1981. Iskut River Saddle Dam - Gravity Survey Extension 1981.

48. Ager, Berretta and Associates, December 1981. Tanzilla - 1981 Gravity Survey (included with HGPD Report No. H1477 as Appendix III).

49. Ager, Berretta and Associates, January 1981. Iskut River Gravity Survey (1980).

50. Ager, Berretta and Associates Inc., September 1980. Tanzilla Site - Aeromagnetic Survey (included with HGPD Report No. H1477 as Appendix VII).

51. Ager, Berretta and Associates Ltd., October 1979. Gravity and Magnetic Survey, Stikine Site Z Survey (included with HGPD Report No. H1166 as Appendix C).

52. Atmex Geophysics Inc., December 1981. Seismic Survey - Iskut Canyon Project - Saddle Dam Area.

53. Atmex Geophysics Inc., May 1981. Stikine Dam Site - Seismic Survey 1981 (included with this report as Appendix B3).

54. Atmex Geophysics Inc., January 1981. Iskut Saddle Dam Site - Seismic Survey 1980.

55. Atmex Geophysics Inc., 1979. Downhole Geophysical Surveys, 1979. Liard, Stikine, Iskut and More Creek, British Columbia.

56. Atmospheric Environment Service, Environment Canada. Update of Critical Meteorological Conditions for Maximum Inflow. Stikine River, B.C. Above Grand Canyon, January 1983.

57. Atmospheric Environment Service, Environment Canada, 1979 and 1983 Critical Meteorological Conditions for Maximum Inflow, Stikine River.

58. B. Chandra and Associates Ltd., January 1982. Bob Quinn Lake (BQB) and Dease Lake (DLB) Seismograph Stations - Northern British Columbia.

59. B. Chandra and Associates Ltd., 1980. Seismic Investigations of Tanzilla Project Site, Stikine River Exploration Program (included with HGPD Report No. H1477 as Appendix IV).

60. Dolmage, Campbell and Assoicates Ltd., February 1983. 1983 Geological Review, Stikine Canyon Project.

61. Dolmage, Campbell and Associates Ltd., August 1982. Supplementary Petrographic Report, Stikine Canyon Project.

62. Dolmage, Campbell and Associates Ltd., June 1982. Geological Review, Stikine Canyon Project.

63. Dolmage, Campbell and Associates Ltd., December 1980. Iskut River Development - Geology of the Iskut Damsite and the More Creek Damsite.

64. Dolmage, Campbell and Associates Ltd., June 1980. Iskut River Development - Petrography.

65. Dolmage, Campbell and Associates Ltd., May 1980. Stikine River, Site Z - Petrography.

66. Dolmage, Campbell and Associates Ltd., December 1979. Iskut-Stikine Projects - Seismic Evaluation.

67. Dolmage, Campbell and Associates Ltd., April 1979. Stikine River Development, Site Z - X-Ray Results.

68. Dolmage, Campbell and Associates Ltd., September 1977. Stikine River Hydroelectric Investigations - Preliminary Geology Report.

69. Energy, Mines and Resources, Canada. Earth Physics Branch, January 1983. One Year of Regional Seismicity Monitoring in Northern British Columbia - Preliminary Results. Pacific Geoscience Centre, Internal Report 83-1.

70. Geo-Physi-Con Co. Ltd., December 1982. Results of a Geophysical Test Survey, Stikine River, B.C.

71. Geotex Consultants Ltd., 1984. Interim Draft - Geological Investigations of Tanzilla Site, Stikine River Project, B.C. 1982.

72. Geotex Consultants Ltd., February 1984. Iskut River Project; Petrography of Samples Collected for Radiometric Dating.

73. Geotex Consultants Ltd., May 1984. 1983 Report: Forrest Kerr Fault System and Related Faults.

74. Geotex Consultants Ltd., 1983. Interim Draft - Quaternary and Late Tertiary Volcanism, Stikine River Projects Area, British Columbia.

75. Geotex Consultants Ltd., 1983 Geological Investigations at Site Z, Stikine River Project, British Columbia, 1982 Report.

76. Geotex Consultants Ltd., March 1983. 1982 Report; Iskut Canyon Project - Regional Geology.

77. Geotex Consultants Ltd., March 1983b. Geological Investigations at Site Z, Stikine River Project, B.C., 1982 Report.

78. Geotex Consultants Ltd., 1982a. Interim Draft - Aspects of the Regional Geology Relevant to Engineering, Stikine River Projects, British Columbia, 1981 Report.

79. Geotex Consultants Ltd., 1982b. Geological Investigations at Site Z, Stikine River Projects, British Columbia, 1981 Report.

80. Geotex Consultants Ltd., June 1982. 1981 Report: Regional Geology and Engineering Aspects of the Iskut Canyon Project, British Columbia.

81. Geotex Consultants Ltd., March 1981a. Petrography of Sample LR1-630 m, Site Z, Stikine River Project.

82. Geotex Consultants Ltd., March 1981b. Petrographic and X-Ray diffraction Analysis of Sample Z - 1765 m, Stikine River Project.

83. Geotex Consultants Ltd., May 1981c. Clay Mineral Analysis of Shales of the Sustut Group, DDH Z80-23 and Z80-26, Site Z, Stikine River.

84. Geotex Consultants Ltd., 1980. Interim Report, Engineering Aspects of the Regional Geology. Stikine River Project, B.C. (included with HGPD Report No. H1314 as Appendix A).

85. Geotex Consultants Ltd., 1979. Geological Investigation of Stikine Reservoir Area and Environs - Preliminary Report.

86. Geotronics Surveys Ltd., August 1979. Seismic Investigation of Stikine River, Site Z, Left Bank (included with HGPD Report No. H1166 as Appendix B).

87. Geotronics Surveys Ltd., September 1978. Seismic Investigation of the Stikine River, Site Z (included with HGPD Report No. H991 as Appendix B).

88. Grove, Edward W. April 1984. Geological Report on Certain Structural Features in the Iskut River Region - Northwestern British Columbia for British Columbia Hydro and Power Authority.

89. C. Howard and Assoc. Ltd., June 1981. Project Oriented Program for Simulation of Hydroelectric Development Projects - User's Manual.

90. HyMet Company, Seattle, Washinton. June 1983. Probable Maximum Floods of the Iskut River, British Columbia.

91. Klohn Leonoff Consultants, August 1983. Slope Stability Investigations, Study Area T1, Tanzilla Reservoir, Stikine River, B.C. Report No. PB7014-01.

92. Klohn Leonoff Consultants, July 1983a. Stikine Canyon Reservoir Studies (Addendum to Report of Investigations - 1981), Stikine River B.C. Report No. PB7014-01.

93. Klohn Leonoff Consultants, July 1982a. Stikine Site Z and Tanzilla Reservoir Studies, Stikine River, B.C. Report No. VA 3201.

94. Klohn Leonoff Consultants, July 1982b. Stikine Slope Stability Study - Tanzilla Powerhouse Area, Stikine River, B.C. Report No. VA 2807.

95. Klohn Leonoff Consultants, March 1980. Stikine-Iskut Hydroelectric Development, Feasibility Study, Preliminary Shoreline Assessment. Report No. VA 2550.

96. McElhanney Surveying and Engineering Ltd., December 1982. Final Report to British Columbia Hydro and Power Authority concerning Iskut Canyon and More Creek Projects.

97. NHRI, Glaciological Studies in Iskut River Basin (1978-83).

98. Pacific Geoscience Centre, Department of Energy, Mines and Resources, Earth Physics Branch, January 1983. One Year of Regional Seismicity Monitoring in Northern B.C. Preliminary Results. Internal Report 83-1.

99. Pedology Consultants, Walmsley, M.E., Maynard, D., February 1983. Soil, Surficial Geology and Landforms Inventory of the Stikine-Iskut Hydroelectric Project.

100. Phoenix Geophysics Ltd., January 1981. Report on the Induced Polarization and Resistivity Survey.

101. Quigley, R.M., February 1984. Report to B.C. Hydro on Preliminary Mineralogical Analysis - Iskut Canyon Project Saddle Dam Area.

102. Quigley, R.M., August 1983. Report to B.C. Hydro on Preliminary Mineralogical Analyses, Stikine River Project, B.C.

103. Shultz International Ltd., August 1983. Development of a Reservoir Water Quality Model for Reservoirs in British Columbia.

104. Stewart-EBA Consulting Ltd., 1983. Laboratory Testing Stikine - Iskut and Other Projects - 1982 Program Contract Q2-1314 (two copies of results collated by BCH, 2 volumes per copy).

105. Stewart-EBA Consulting Ltd., May 1982. 1981/82 Laboratory Testing Program, Stikine - Tanzilla Project.

106. Stirland Engineering Ltd., November 1981. Stikine Canyon Project, Report on Concrete Aggregates.

107. Tangborn, Albright, La Chapelle, March 1982. Autumn Floods of the Iskut River.

108. Thurber Consultants Ltd., 1984. B.C. Hydro, 1983/84 Rock Testing Program, Contract Q3-1833.

109. Thurber Consultants Ltd., 1983. Laboratory Testing Liard and Construction Materials - 1982 Program Contract Q2-1230 (two copies of results collated by BCH, 6 volumes per copy).

110. Underhill Engineering Ltd. Field Surveys 1982, File No. 81-21.

111. Weir-Jones Engineering Consultants Ltd., August 1983. B.C. Hydro, Stikine - Iskut Development, Rock Testing Program 1981-1982.

ENVIRONMENTAL

1. Aquatic Environments Ltd., September, 1983. Report on Fish Surveys in Reservoir Areas, Stikine and Iskut Drainages 1980.

2. Aquatic Environments Ltd., May 1982. Fish Populations Associated with Proposed Hydroelectric Dams on the Stikine and Iskut Rivers; Volume I, Baseline Studies.

3. Aquatic Environments Ltd., May 1982. Fish Populations Associated with Proposed Hydroelectric Dams on the Stikine and Iskut Rivers; Volume III Appendix.

4. Aquatic Environments Ltd., August 1982. Tahltan Fry Enumeration Study.

5. Aquatic Environments Ltd., March 1983. Studies of Salmon Spawning in the Stikine River 1982.

6. Aquatic Environments Ltd., March 1983. Late Winter Survey, Sockeye Spawning Habitat, Stikine River.

7. Aquatic Environments Ltd., September 1983. Fish Populations Associated with Proposed Hydroelectric Dams on the Stikine and Iskut Rivers; Volume II, Preliminary Assessment of Potential Impact.

8. Aquatic Environments Ltd., June 1984. Continued Monitoring and Selected Studies of Salmon Populations in the Canadian Segment of the Stikine River Drainage.

9. Aresco Ltd., April 1980. Preliminary Archaeological Study of the Proposed Stikine-Iskut Hydroelectric Development.

10. Aresco Ltd., Janary 1983. Heritage Resource Inventory; Construction Materials Exploration Areas and Selected Ancillary Facilities; Stikine-Iskut Development; Permit 1982-16.

11. Aresco Ltd., march 1982. Stikine-Iskut Hydroelectric Project Heritage Resource Impact Assessment 1980/81.

12. B.C. Hydro, System Engineering Division, Generation Planning Department. December 1980. Stikine-Iskut Rivers Hydroelectric Project Environmental Studies. Economic Geology.

13. B.C. Hydro, Engineering Services Division, Environmental and Socioeconomic Services Department. March 1981. Caribou Survey Data and Snow Depth in Vicinity of Spatsizi Plateau, 1980.

14. B.C. Hydro, Engineering Services Division, Environmental and Socio-economic Services Department. January 1982. Habitat Utilization by Ungulates and Other Wildlife in the Proposed Reservoir Areas on the Stikine and Iskut Rivers. A summary report of the 1979 and 1980 field studies.

15. B.C. Hydro May 1984. Stikine-Iskut Development, Report on Stage 1 Settlement Studies. Report No. H1544.

16. B.C. Hydro, Hydroelectric Generation Projects Division - Hydrology July 1984. Fish Habitat and Hydrology Studies of Juvenile Chinook Physical Habitat, Lower Stikine Test Reach. Report No. H1739.

17. B.C. Hydro, Hydroelectric Generation Project Division - Hydraulics, November 1984. Stikine-Iskut Downstream Water Temperature Study.

18. Beak Consultants Ltd., September 1981. Preliminary Analysis of the potential Impact of Hydroelectric Development of the Stikine River System on Biological Resources of the Stikine Estuary.

19. Beak Consultants Ltd., 1982. Analysis of the Potential Impacts of Hydroelectric Development of the Stikine River System in Alaska.

20. Beak Consultants Ltd., March 1982. Preliminary Data Appendix, Physical Studies, Stikine Estuary.

21. D.A. Blood and Associates June 1982a. Stikine-Iskut Hydroelectric Projects, Supplementary Wildlife Studies.

22. D.A. Blood and Associates June 1982b. Potential Impacts of Stikine-Iskut Hydroelectric Project on Bears.

23. D.A. Blood and Associates July 1982c. A Preliminary Evaluation of Potential Impacts of Stikine-Iskut Hydroelectric Developments on Wildlife.

24. Canadian Resourcecon Ltd./Bentley Le Baron August 1982. Stikine-Iskut Projects - Social and Economic Impacts.

25. D.P. Jones and Associates and Hydroelectric Generation Projects Division August 1983. Stikine-Iskut Development; Environmental Hydrology Report; Volume I; Hydrology, Sediment Transport and Morphology of the Stikine and Iskut Rivers.

26. Eikos Ltd., December 1983. Stikine-Iskut General Land Use Studies.

27. Forestal International Ltd., April 1980. Forest Impact Study. Stikine-Iskut Environmental Studies.

28. Forstal International Ltd., May 1982. Addendum to Stikine-Iskut Forest Impact Study.

29. I.R. Wilson Consultants Ltd., April 1984. Stikine-Iskut Development, Heritage Resources Impact Assessment Summary Volume, Permit 1983-35.

30. IEC/Beak Ltd., 1983. Report on Hydrology Measurements and Fish Sampling in a Test Reach on the Alaskan Stikine River.

31. IEC/Beak Ltd., January 1983. Analysis of the Potential Impacts of Hydroelectric Development of the Stikine River System in Alaska; Addenda on Eulachon Spawning.

32. IEC/Beak Ltd., November 1983. Analysis of the Potential Impacts of Hydroelectric Development of the Stikine River System in Alaska. Addendum on Salmon Utilization of Floodplain Habitats.

33. Life-Space Designs Ltd., April 1981. Visual Analysis of the Proposed Stikine River Hydroelectric Project.

34. Marr-Terr Enviro Research Ltd., July 1981. Relationship between Mountain Goat Ecology and Proposed Hydroelectric Development on the Stikine River.

35. McCourt Management Ltd., April 1981. Studies on Fur Bearing Mammals in the Stkine River Drainages.

36. McCourt Mangement Ltd., April 1982. Studies on Fur Bearing Mammals in the Stikine River Drainages.

37. P. McCart Biological Consultants ltd., April 1980. Stikine-Iskut Fisheries Studies 1979.

38. Pedology Consultants Ltd., February 1983. Soil, Surficial Geology and Landforms Inventory of the Stikine-Iskut Hydroelectric Project.

39. Schultz International Ltd., March 1984. Stikine-Iskut Hydroelectric Development; Effect of a Submerged Weir Algorithm on Outflow Temperatures.

40. Schultz International Ltd. and Ford, Thornton, Norton and Associates Ltd., March 1984. Development of a Reservoir Water Quality Model for Reservoirs in British Columbia.

41. Schultz International ltd., and Ford, Thornton, Norton and Associates Ltd., March 1984. Manager: A Numerical one dimensional Model of Reservoir Model Quality; User's Manual.

42. Talisman Land Resource Consultants May 1982. Stikine-Iskut Hydroelectric Development Wildlife Habitat Mapping Study.

43. Talisman Land Resource Consultants January 1982. Agricultural Overview. Stikine-Iskut Hydroelectric Development.

44. Technology Resource Inc., March 1984. Stikine-Iskut Hydroelectric Development; Simulation of Selective Withdrawal and its Effect on Release Temperatures.

TRANSMISSION

ENGINEERING

1. System Engineering Division, B.C. Hydro, February 1983. Stikine/Iskut Project - Steady State and Dynamic Performance.

2. System Engineering Division, B.C. Hydro, December 1982. Preliminary Planning Report for the Stikine/Iskut Transmission.

3. Transmission Projects Division, B.C. Hydro, October 1982. Preliminary Route Engineering Assessment of the Stikine/Iskut Transmission System.

4. System Engineering Division, B.C. Hydro, July 1980. Northern Hydro System Development, Volume III - Combined Liard and Stikine/Iskut Integration.

5. System Engineering Division B.C. Hydro, July 1980. Prospectus, Northern Transmission Studies, Electrical Energy Transmission from Potential Hydroelectric Generation Projects on the Stikine/Isut and Liard River.

6. System Engineering Division, B.C. Hydro, June 1980. Northern Hydro System Development Rport, Volume [illegible] - Stikine-Iskut Integration.

7. System Design Division, B.C. Hydro, October 1979. Report on Northern Hydro Development Transmission Studies.

ENVIRONMENTAL

1. Ian Hayward and Associates, September 1979. Northern Transmission Overview Study, Text Volume.

2. Ian Hayward and Associates, September 1979. Northern Transmission Overview Study, Map Volume.

3. Ian Hayward and Associates, July 1982. Preliminary Environmental and Social Impact Assessment of the Stikine/Iskut Transmission System, Volume I Main Volume.

4. Ian Hayward and Associates, July 1982. Preliminary Environmental and Social Impact Assessment of the Stikine/Iskut Transmission System, Volume 2 - Stikine Plateau - Coast Mountains Region.

5. Ian Hayward and Associates, July 1982. Preliminary Environmental and Social Impact Assessment of the Stikine/Iskut Transmission System, Volume 3 - Nass Basin - Hazelton Mountains Region.

6. Ian Hayward and Associates, July 1982. Preliminary Environmental and Social Impact Assessment of the Stikine/Iskut Transmission System, Volume 4 - Skeena Mountains - Nechako Plateau Region.

7. Ian Hayward and Associates, June 1982. Preliminary Environmental and Social Impact Assessment of the Stikine/Iskut Transmission System, Appendix.

8. Hugh Hamilton Ltd., October 1982. Northern Transmission/Stikine Study Forestry Resources.

9. DPA Consultants Ltd., February 1982. Stikine/Iskut Transmission Project, Socioeconomic Study, Phase 1.

10. Public Affairs Division, B.C. Hydro, May 1981. Electricity in Northwestern British Columbia.